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**THESIS**

**“PROBABLE CAUSE” FOR MARITIME INTERDICTIONS  
INVOLVING ILLICIT RADIOACTIVE MATERIALS**

by

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December 2008

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Existing international frameworks that govern maritime interdiction entitle the boarding of a vessel in international waters only if justified by reasonable grounds to suspect that the vessel is engaged in illicit activity, a legal concept similar to the U.S. principle of "probable cause." Given recent advances in radiation detection technology, this thesis considers how this concept could be strengthened by the use of detectors for maritime interdiction of illicit radioactive materials, a problem that spans both policy and technical issues. To address this problem, the thesis incorporates analysis of both legal and technical factors related to detection of illicit radioactive materials. It includes a comprehensive compilation and examination of the legal and institutional issues related to probable cause determination, as well as technical evaluations of a state-of-the-art remote radiation detection system known as the Adaptable Radiation Area Monitor (ARAM) to determine its suitability in supporting probable cause determinations in a maritime environment. Based on these technical evaluations and an understanding of the legal and institutional issues related to probable cause determination, I conclude that radiation detection technology offers great promise in promoting effective interdiction operations that will improve safety and reduce the risk of illicit transport of radioactive materials.

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ILLICIT RADIOACTIVE MATERIALS**

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## ABSTRACT

Existing international frameworks that govern maritime interdiction entitle the boarding of a vessel in international waters only if justified by reasonable grounds to suspect that the vessel is engaged in illicit activity, a legal concept similar to the U.S. principle of “probable cause.” Given recent advances in radiation detection technology, this thesis considers how this concept could be strengthened by the use of detectors for maritime interdiction of illicit radioactive materials, a problem that spans both policy and technical issues. To address this problem, the thesis incorporates analysis of both legal and technical factors related to detection of illicit radioactive materials. It includes a comprehensive compilation and examination of the legal and institutional issues related to probable cause determination, as well as technical evaluations of a state-of-the-art remote radiation detection system known as the Adaptable Radiation Area Monitor (ARAM) to determine its suitability in supporting probable cause determinations in a maritime environment. Based on these technical evaluations and an understanding of the legal and institutional issues related to probable cause determination, I conclude that radiation detection technology offers great promise in promoting effective interdiction operations that will improve safety and reduce the risk of illicit transport of radioactive materials.

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## I. INTRODUCTION

### A. MAJOR RESEARCH QUESTION

The existing framework governing maritime interdictions, as established by international law, the Proliferation Security Initiative's Statement of Interdiction Principles, and bilateral ship-boarding agreements, permits the boarding of a vessel only if such an action is justified by "such vague formulae as reasonable ground to suspect or good cause to believe that the vessel is engaged in illicit activity."<sup>1</sup> Similarly, United States law permits enforcement action, such as arrest or seizure, only under the prerequisite of probable cause, i.e., "a reasonable belief that a person has committed a crime."<sup>2</sup> This analogy between maritime law and homeland security can be further expanded. In policing highways, police patrols already have at their disposal portal radiation detection monitors in order to establish reasonable suspicion before stopping and searching a commercial vehicle suspected of carrying radioactive materials.<sup>3</sup> Given the advances of such technology for further deployment onboard maritime platforms, the argument of this thesis is that establishing criteria for determining "probable cause" in maritime interdictions of illicit radioactive materials could be promoted on the same basis as in homeland security activities, which, at the international level, represents a unique overlap between policy and technical issues.

Existing scholarship addressing these issues so far has generally fallen into two rather distinct categories and has remained confined within their respective fields of expertise. The first consists of social and political science literature, which is preoccupied with questions of legality and proper authority, while associating reasonable suspicion

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<sup>1</sup> Craig H. Allen, *Maritime Counterproliferation Operations and the Rule of Law* (Westport, Conn: Praeger Security International, 2007), 65-66.

<sup>2</sup> Lectric Law Library's Lexicon, "Probable Cause," Lectric Law Library, <http://www.lectlaw.com/def2/p089.htm>.

<sup>3</sup> Lawrence Livermore National Laboratory. Science and Technology, "Detecting Radiation on the Move," Lawrence Livermore National Laboratory, <https://www.llnl.gov/str/October05/Archer.html>.

almost solely with intelligence,<sup>4</sup> whether complemented or not by reconnaissance information.<sup>5</sup> The second consists of physics literature, which focuses on radiation detection research, pure or applied, to cover the existing deficits in counter-proliferation operations. This thesis will combine the findings of both in an effort to answer the research question: how can a notion of “probable cause” be established for maritime interdictions involving illicit radioactive materials?

## B. IMPORTANCE

The importance of establishing probable cause for maritime counter-proliferation operations is twofold: both macroscopic and microscopic. On a macroscopic level, since the early 1990’s and especially in the aftermath of the September 11, 2001, terrorist attacks, defense analysts, technical experts and international organizations (such as the International Atomic Energy Agency) have warned of the rising nuclear terrorist threat.<sup>6</sup> These concerns, in conjunction with the exposure of the A.Q. Khan network in early 2004 that had sold nuclear-related technology and materials to North Korea, Libya, and Iran, were officially expressed on behalf of the world community on April 28, 2004, by the United Nations Security Council (UNSC) Resolution 1540. This resolution stated that “[t]he proliferation of nuclear [...] weapons, [...] constitutes a threat to international peace and security.”<sup>7</sup> Keeping in mind that the oceans make up more than 70% of the

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<sup>4</sup> Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 60; Andreas Persbo and Ian Davis, “Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea,” *British American Security Information Council Research Report* 2 (2004): 37-9; Joel A. Doolin, “The Proliferation Security Initiative: Cornerstone of a New International Norm,” *Naval War College Review* 59, no. 2 (Spring, 2006): 29, 38; Mark R. Shulman, “The Proliferation Security Initiative As A New Paradigm For Peace And Security,” Strategic Studies Institute of the U.S. Army War College (April 1, 2006), 16.

<sup>5</sup> Denise Hammick, “Navies endeavour to police the Mediterranean Sea,” *Jane’s Navy International* (July 1, 2007), <http://www8.janes.com.libproxy.nps.edu/Search/documentView.do?docId=/content1/janesdata/mags/jni/history/jni2007/jni71286.htm@current&pageSelected=allJanes&keyword=Navies>.

<sup>6</sup> BBC news sec. Europe, “UN warns of nuclear terrorist threat,” BBC news, <http://news.bbc.co.uk/1/hi/world/europe/1634464.stm>; International Atomic Energy Agency and Europol, *Combating illicit trafficking in nuclear and other radioactive material reference manual* (Vienna: International Atomic Energy Agency, 2007), 3, [http://www-pub.iaea.org/MTCD/publications/PDF/pub1309\\_web.pdf](http://www-pub.iaea.org/MTCD/publications/PDF/pub1309_web.pdf).

<sup>7</sup> United Nations, “Non-Proliferation of Weapons of Mass Destruction,” United Nations Security Council Resolution 1540, 2004, [http://www.un.org/Docs/sc/unsc\\_resolutions04.html](http://www.un.org/Docs/sc/unsc_resolutions04.html).

earth's surface and that maritime trade accounts for almost 80% of world trade,<sup>8</sup> as well as that in the Mediterranean Sea alone “there are around 7000 ships,” at any time<sup>9</sup> the importance of maritime security in countering nuclear proliferation and terrorism is self-evident.

On a microscopic level, probable cause in maritime interdiction is a prerequisite for both normative and practical reasons. First, failure of the proclaimed cause (i.e., “if the suspicions prove to be unfounded, and provided that the ship boarded has not committed any act justifying them”<sup>10</sup>) automatically means that “it shall be compensated for any loss or damage that may have been sustained.”<sup>11</sup> Second, a complete lack of probable cause implies lack of legitimacy under international law. Third, keeping in mind the scarce numbers of warships compared to merchant vessels on a global scale,<sup>12</sup> if an international actor should choose to disregard the established legal framework, “blind” interdictions which were not based on any prior surveillance, intelligence or radiation detection sensors would prove fruitless beyond any level of acceptable cost-effectiveness.

As mentioned, the existing policy and legal framework associates probable cause with the vague enunciation of “reasonable ground to suspect or good cause to believe that a vessel is engaged in illicit activity.”<sup>13</sup> This vagueness has in turn sparked debates among scholars and experts over the legal justification for maritime interdictions<sup>14</sup> and how to set a threshold that demarcates a suspect from a non-suspect vessel.<sup>15</sup> Since

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<sup>8</sup> Michael Richardson, *A time bomb for global trade maritime-related terrorism in an age of weapons of mass destruction* (Pasir Panjang, Singapore: Institute of Southeast Asian Studies, 2004), 3.

<sup>9</sup> Hammick, “Navies endeavour to police the Mediterranean Sea,” 2.

<sup>10</sup> United Nations, “Convention on the Law of the Sea,” Montego Bay: UNCLOS, 1982. [http://www.un.org/Depts/los/convention\\_agreements/texts/unclos/closindx.htm](http://www.un.org/Depts/los/convention_agreements/texts/unclos/closindx.htm) (Right of visit, Article 110).

<sup>11</sup> Ibid.

<sup>12</sup> Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 62.

<sup>13</sup> Ibid., 65-66.

<sup>14</sup> Barry W. Coceano, “The Proliferation Security Initiative: Challenges and Perceptions,” The Atlantic Council of the United States, Occasional Paper (May 2004), 15, <http://se1.isn.ch/serviceengine/FileContent?serviceID=ISN&fileid=B98F0C0F-E2F7-8A69-831A-EAC61CC732D0&lng=en>.

<sup>15</sup> Allen defines it as the “quantum of suspicion necessary to justify PSI actions.” See Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 158.

thresholds are more easily set on raw numerical data than on intangible verbal concepts, this thesis will explore the potential of radiation detection technology developments for overcoming these probable cause issues beyond any legal interpretations, the credibility of intelligence and the subjectivity of commentators and scholars.

One promising system that is currently being evaluated by authorities in the U.S. is the Adaptable Radiation Area Monitor (ARAM), developed by the Lawrence Livermore National Laboratory and by Textron Systems. ARAM is an instrument with the potential to promote the valid and credible classification of a vessel as reasonably suspect beyond the easily debatable concepts of erratic behavior and credible intelligence. It offers real-time detection and identification of “radioactive materials as well as medical and industrial isotopes that may be used to make dirty bombs or radiological weapons.” It has also been designated by the U.S. Department of Homeland Security (DHS) as “a Qualified Anti-Terrorism Technology under the Support Anti-terrorism by Fostering Effective Technologies Act (SAFETY Act),” and it can be deployed in a maritime version (known as an “ARAM RadBoat”).<sup>16</sup>

### C. PROBLEMS AND HYPOTHESES

Properly addressing this research question requires answers to a series of relevant sub-questions and problems. The first is, “What constitutes illicit nuclear or other radioactive material?” The potential dual use of radioactivity for applications in both war and peace was acknowledged very early on. Several radioactive isotopes are being used for peaceful purposes in medicine, industry, agriculture and science. Nevertheless, they can easily be turned into Radiological Dispersal Devices (RDDs), also known as “dirty bombs.”<sup>17</sup>

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<sup>16</sup> U.S. Department of Homeland Security. Safety Act, “Textron Systems Corporation.: Adaptable Radiation Area Monitor (ARAM)” (February 29, 2008), <https://www.safetyact.gov/DHS/SActHome.nsf/Designations?ReadForm>; Textron Systems, “Adaptable Radiation Area Monitor Designated as a Qualified Anti-Terrorism Technology” (March 24, 2008), [http://www.textronsystems.com/news/2008/03\\_24\\_08.htm](http://www.textronsystems.com/news/2008/03_24_08.htm).

<sup>17</sup> Abel J. Gonzalez, “Security of Radioactive Sources: The Evolving New International Dimensions,” *IAEA Bulletin* 43, no. 4 (2001), 39, <http://www.iaea.org/Publications/Magazines/Bulletin/Bull434/article8.pdf>; International Atomic Energy Agency and Europol, *Combating illicit trafficking in nuclear and other radioactive material reference manual*, 3-6.

This potential dual use in turn poses the question, “When does transporting nuclear or other radioactive materials constitute an unlawful act?” When boarding a vessel transporting relevant cargo, the answer to this question draws a distinct line between a successful counter-proliferation operation and the disruption of legitimate shipping, which conspicuously violates “one of the key tenets of the law of the sea, freedom of navigation.”<sup>18</sup>

Thereafter, the questions “Who constitutes the proper authority to interdict the materials in question?” and “What is the legitimate reach of this authority?” are addressed. The Law of the Sea divides the oceans into various domains (such as territorial, contiguous, and international waters) and attributes specific rights and obligations to concerned international actors (a vessel’s flag state, the coastal state, and the interdicting state).

Finally, the question of how to justify probable cause is at the same time the foundation for and the cornerstone of every maritime interdiction. It is necessary for both the initiation and post facto justification of the operation to the international community. Approaches to approaches to resolving this problem include intelligence, activity monitoring of merchant vessels complemented by “hailing” procedures,<sup>19</sup> and developing radiation detection technology for maritime platforms.<sup>20</sup>

The on-demand development of radiation detection technology to meet post-September 11, 2001 security needs focuses on several purely technical and practical issues. Merchant vessels present a particularly high level of difficulty in detecting radiation sources. First of all, they are moving platforms. Second, in sharp contrast to highways, global sea lines of communication (SLOCs) are not fixed. Consequently, no fixed control points exist. The concept of operations for these radiation detection monitors involves their deployment on small, usually rigid-hulled inflatable boats

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<sup>18</sup> Persbo and Davis, “Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea,” 7.

<sup>19</sup> Roberto Cesaretti, “Combating terrorism in the Mediterranean.” *NATO Review* (Autumn 2005), <http://www.nato.int/docu/review/2005/issue3/english/art4.html>.

<sup>20</sup> Textron Systems, “Adaptable Radiation Area Monitor Designated as a Qualified Anti-Terrorism Technology.”

(RHIBs) that conduct “passes” in close proximity to suspect vessels. However, although every major warship has an RHIB (or similar vessel) available, the huge size of most commercial ships and their complicated physical structure, comprised of multiple decks and bulkheads with a considerable amount of heavy machinery, increases the distance from and the shielding of any potential radioactive source. Moreover, due to the aforementioned dual use of isotopes in peaceful applications and to the omnipresence of significant (in terms of detectability) radiation in such innocent cargo as a load of bananas,<sup>21</sup> the portable monitors need to have not only the ability to detect radiation but also to identify specific sources.

Thus, in order to draw a measure of effectiveness for any maritime radiation area monitor, apart from an optimal speed of the “pass” by the suspect vessel, two theoretical concentric circles with the monitor as datum should be constructed for each tested source; an inner one representing the maximum range of both detection and credible identification, and an outer one representing the extreme limit of detection even with poor or no identification results.

#### **D. LITERATURE REVIEW**

The term “probable cause” is intimately connected with law enforcement in social science. However, as Hedley Bull points out, the existing order in world politics resembles more closely an “anarchical society,”<sup>22</sup> a concept that is especially relevant for the greatest part of the world’s oceans, where no absolute and sovereign authority applies. A short-lived debate between John Selden, who advocated *mare clausum*, and Hugo Grotius, who advocated *mare liberum*, took place during the 17<sup>th</sup> century.<sup>23</sup> The latter prevailed and became incorporated as the *freedom of the high seas* in the customary law of the sea. It was much later formalized within the 1982 United Nations Convention on the Law of the Sea (UNCLOS, Article 87). Thus, in policing highways legitimacy is

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<sup>21</sup> Ronald D. White, “Detectors may Cause Port Delays,” *Los Angeles Times*, May 7, 2005.

<sup>22</sup> Hedley Bull, *The Anarchical Society: A Study of Order in World Politics* (New York: Columbia University Press, 2002).

<sup>23</sup> Natalie Klein, “Legal Limitations on Ensuring Australia’s Maritime Security,” *Melbourne Journal of International Law* 7, no. 2 (2006): 310.

axiomatic and only evidence of suspicion needs to be provided, in policing SLOCs justification of probable cause has to provide both reason for suspicion and legality under UNCLOS. These issues represent an area of debate among scholars, especially in terms of how they are addressed by such organizations and activities as the Proliferation Security Initiative (PSI), NATO's Operation Active Endeavour (OAE), and the Global Initiative to Combat Nuclear Terrorism, with the PSI receiving the lion's share of attention.

Despite the fact that the UNCLOS is largely perceived to be “the most comprehensive political and legislative work” ever created under the aegis of the United Nations,<sup>24</sup> it is still, as is every piece of legislation, open to a fair amount of interpretation. As detailed in Yann-Huei Song’s study of commentators (including Benjamin Friedman, Devon Chaffee, Michael Byers, Andrea Persbo, Ian Davis and several others)<sup>25</sup> on the question of PSI legality under UNCLOS, interpretation is in turn subject to different individual points of view, schools of thought, and interests advocated by various international actors. This has lead to a wide spectrum of ardent supporters, deprecatory critics, and irresolute or ambiguous commentators on the subject. Song’s overall assessment leads to the conclusion that the PSI, as a system of bilateral and multilateral agreements based on consent, is in conformity with international law, with the caveat that the latter conclusion may not render legal every maritime interdiction undertaken by it in all circumstances. Each real or hypothetical scenario needs to be examined on a case-by-case basis, while in parallel focusing on the three major fields where the rights and obligations of the concerned parties may overlap with one another. These are, in turn, the cargo type of the interdicted ship, the maritime domain of the

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<sup>24</sup> Yann-Huei Song, “The U.S.-Led Proliferation Security Initiative and UNCLOS: Legality, Implementation, and an Assessment,” *Ocean Development and International Law* 38, no. 1/2 (January 2007): 102.

<sup>25</sup> Ibid., 113.

interdiction (i.e., territorial, contiguous, or international waters), and the flag under which the vessels in question sails,<sup>26</sup> coinciding with the “what,” “when,” and “who” questions of this thesis.

Song’s conclusion shares a great degree of consensus among scholars, as does the fact that in certain cases law can be interpreted in a wider context,. Thus, several legal clauses are put forth for justification of probable cause, when such justification falls short of the strict UNCLOS context. One such clause suggested by Allen is the customary law of unilateral self-help countermeasures.<sup>27</sup> Though possibly unlawful under other conditions and restrained by the United Nations Charter, provisions on the use of force and self-help actions gain legitimacy if intended as a proportionate response to an ongoing or intended violation. After acknowledging Myres McDougal’s view that such countermeasures are appropriate due to the lack of a global sovereign authority,<sup>28</sup> Allen argues that apart from UNCLOS Article 110, which clearly defines the cases when the *right of visit* applies in the high seas, Articles 25 and 221 connote self-help, stating that a “coastal state may resort to extrajudicial countermeasures” within and beyond its territorial waters by invoking respectively a *non-innocent passage* or pollution-related reasons.

In a similar context, another debate among experts regards the prospect presented by PSI of *creating* rules of customary international law to justify boarding, instead of merely applying them. Song, based on the record of previous PSI activities, argues that this possibility is not likely to become a reality, due to the absence of “a general practice of states in undertaking interdictions.”<sup>29</sup> On the other side, Doolin, expressing a more

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<sup>26</sup> Song, “The U.S.-Led Proliferation Security Initiative and UNCLOS: Legality, Implementation, and an Assessment,” 113-114.

<sup>27</sup> Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 135-138.

<sup>28</sup> Myres S. McDougal, “Authority to Use Force on the High Seas,” *U.S. Naval War College International Law Studies* 61 (1979): 551, 555 as cited in Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 135.

<sup>29</sup> Song, “The U.S.-Led Proliferation Security Initiative and UNCLOS: Legality, Implementation, and an Assessment,” 134.

general expectation, claims that through the cluster of PSI agreements, exercises, and interdictions, boarding a vessel suspected of carrying WMD materials will gradually evolve into a widely accepted practice.<sup>30</sup>

Yet another claim, mentioned but not advocated by Allen<sup>31</sup> and Doolin,<sup>32</sup> is that of belligerent status in the global war on terror. Doolin points out that a prerequisite for such an invocation would be “an enabling resolution or formal declaration of war by the [United States] Congress,” which, though applicable against a specific state, becomes irrelevant against a non-state actor. As a result, his overall assertion concludes that belligerent status should only be invoked in conventionally defined war scenarios.<sup>33</sup>

A more realistic potential alternative, cited by Persbo and Davis<sup>34</sup> and Allen<sup>35</sup> is the doctrine of necessity. Attributed to Hugo Grotius,<sup>36</sup> the doctrine of necessity justifies an otherwise unlawful action when “the existence of a state is in peril.”<sup>37</sup> While Persbo and Davis, and Allen use two different examples of appeal to necessity, their deductions are quite similar. Allen refers to the motor vessel (M/V) *Saiga* case,<sup>38</sup> in the aftermath of which he qualifies the necessity justification at the same time as “tempting” and “coming at cost” (cost in this case referring to both the need to international legal structure). On the other hand, Persbo and Davis cite the successful necessity implementation of the M/V *Torrey Canyon* case,<sup>39</sup> which sets a legal precedent. Hence, in a hypothetical scenario where there is solid ground to believe that a WMD cargo is underway on the high seas,

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<sup>30</sup> Doolin, “The Proliferation Security Initiative: Cornerstone of a New International Norm,” 50-51.

<sup>31</sup> Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 92.

<sup>32</sup> Doolin, “The Proliferation Security Initiative: Cornerstone of a New International Norm,” 45.

<sup>33</sup> Ibid.

<sup>34</sup> Persbo and Davis, “Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea,” 10, 78-81.

<sup>35</sup> Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 173-174, 187.

<sup>36</sup> Hugo Grotius, *The Law of War and Peace: De Jure Belli Ac Pacis Libri Tres*, trans. Francis W. Kelsey (Indianapolis: Bobbs-Merrill, 1962).

<sup>37</sup> Persbo and Davis, “Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea,” 78.

<sup>38</sup> This case is described fully in Chapter III.

<sup>39</sup> This case is described fully in Chapter III.

PSI states could claim interdiction as the only course of action to protect themselves against a “grave and imminent peril.”<sup>40</sup> Even so, given the failure and consequent discrediting of intelligence in the last Iraq war,<sup>41</sup> Persbo and Davis regard such a course of action only as a last resort in exceptional cases. If, instead of the exception, the necessity justification became the rule, it would then constitute an abuse of right under international law.<sup>42</sup>

Another doctrine also proposed by Persbo and Davis, Shulman, Coceano, Allen, and Doolin is that of “pre-emptive” or “anticipatory” self-defense based on Article 51 of the United Nations Charter. Doolin goes further in providing examples of such implementation in maritime interdiction operations, namely the Cuban Missile Crisis of 1962, Operation Noah’s Ark by Israel in 2002, and the seizure of conventional weapons by Spain in 2003. It is noteworthy that none of these operations was judged illegal under international law.<sup>43</sup> Nonetheless, the final lesson of each is that pre-emptive self-defense should be used again as a last resort option.<sup>44</sup> For all that, Doolin concludes that “the remedy is amendment, not reinterpretation.”<sup>45</sup>

Persbo and Davis, as early as 2004, suggested ways of strengthening legality in cases when UNCLOS does not permit maritime interdictions through the International Maritime Organization (IMO) and the United Nations Security Council (UNSC). More specifically, they suggested amending the 1988 Convention on the Suppression of

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<sup>40</sup> Persbo and Davis, “Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea,” 80.

<sup>41</sup> Ibid., 10, 80. Another report refers to: “[S]pectacularly bad intelligence prepared by the IC in the run-up to the war in Iraq.” See U.S. Senate Select Committee on Intelligence, “Report on Whether Public Statements Regarding Iraq by U.S. Government Officials were substantiated by Intelligence Information,” U.S. Senate Select Committee on Intelligence Publications 110<sup>th</sup> Congress, 2<sup>nd</sup> Session (June 2008), 170, <http://intelligence.senate.gov/080605/phase2a.pdf>.

<sup>42</sup> Persbo and Davis, “Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea,” 81.

<sup>43</sup> Doolin, “The Proliferation Security Initiative: Cornerstone of a New International Norm,” 47.

<sup>44</sup> Persbo and Davis, “Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea,” 89; Shulman, “The Proliferation Security Initiative As A New Paradigm For Peace And Security,” 27; Allen, *Maritime counterproliferation operations and the rule of law*, 138-140; Coceano, “The Proliferation Security Initiative: Challenges and Perceptions,” 15.

<sup>45</sup> Doolin, “The Proliferation Security Initiative: Cornerstone of a New International Norm,” 46-48, 50.

Unlawful Acts against the Safety of Maritime Navigation (SUA) by making radioactive material transport an “internationally recognized offence” and the adoption of a resolution which would grant states the *de jure* right of combating nuclear proliferation on the high seas similar to the already vested right of combating piracy and the slave trade.<sup>46</sup>

Regarding legal limitations on maritime counter-proliferation operations, Natalie Klein, focusing more on the policy aspect, finds them to be “indicative of deficiencies in the very nature of the law of the sea.”<sup>47</sup> Writing after the proposed SUA amendment had taken official form under Article 3bis of the 2005 SUA Protocol of Amendment<sup>48</sup> (which still awaits ratification for entry into force<sup>49</sup>). Klein considers the protocol to be promoting the counter-proliferation initiatives as a legally binding instrument that is consistent with UNCLOS.<sup>50</sup> She pinpoints as a main deficiency in both of these conventions the exclusive authority of the flag state on the high seas and advocates that a slight encroachment of this authority at the behest of maritime security so as to promote probable cause.<sup>51</sup>

Apart from the debates surrounding legal justification, there is currently a wide degree of consensus that establishing reasonable suspicion to board a vessel at sea is based on intelligence and reconnaissance. This is attested to by scholars (Allen, Persbo and Davis, Doolin, and Shulman),<sup>52</sup> military officials (Vice Admiral Italian Navy

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<sup>46</sup> Persbo and Davis, “Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea,” 75.

<sup>47</sup> Klein, “Legal Limitations on Ensuring Australia’s Maritime Security,” 309.

<sup>48</sup> As cited in Allen, *Maritime counterproliferation operations and the rule of law*, 218-219.

<sup>49</sup> IMO website, “Summary of Status of Conventions,” as of March 31, 2008, <http://www.imo.org/>.

<sup>50</sup> IMO Legal Committee, “Report of the Legal Committee on the Work of Its Eighty-Eighth Session,” LEG 88/13, 88th sess, Agenda Item 13 (18 May 2004) [66]. as cited in Klein, “Legal Limitations on Ensuring Australia’s Maritime Security,” 329.

<sup>51</sup> Klein, “Legal Limitations on Ensuring Australia’s Maritime Security,” 337.

<sup>52</sup> According to Shulman: “How Does the PSI Work: Intelligence Sharing and Operational Cooperation.” See Shulman, “The Proliferation Security Initiative As A New Paradigm For Peace And Security,” 16. For other sources with similar context see Allen, *Maritime counterproliferation operations and the rule of law*, 60; Persbo and Davis, “Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea,” 37-39; Doolin, “The Proliferation Security Initiative: Cornerstone of a New International Norm,” 29, 38.

Roberto Cesaretti, former commander of NATO Operation Active Endeavour,<sup>53</sup> and Rear Admiral Richard Leaman, former Chief of Staff for NATO's Maritime Component Command [CC-Mar] Naples and OAE ships' commanding officers<sup>54</sup>), and most of all by the ongoing activities of NATO and PSI member states' naval units.<sup>55</sup> The latter rely on "hailing procedures" regarding merchant vessels transiting through their patrol areas (i.e., calling them on a VHF channel, asking questions about the ship's identity, cargo and activity, and visually identifying them), mostly using their own helicopters and monitoring their movements for as long they remain within sensors range. This data is then evaluated and correlated with intelligence information. If a vessel presents an erratic behavior profile (e.g. zigzagging, lowering and raising its flag),<sup>56</sup> if anything unusual appears during the "hailing procedure,"<sup>57</sup> and/or if the vessel is classified as suspect based on intelligence, appropriate action may be taken for interdiction in compliance with the law of the sea and with the prior consent of the ships' masters and flag states when a non-compliant boarding is not in conformity with international law.<sup>58</sup>

While most social scientists, like Shulman, acknowledge the "difficulty of detecting or seizing such [nuclear] materials at sea,"<sup>59</sup> they disregard the technical aspects of it and make the probable cause issue only one for "policymakers, soldiers, diplomats, and lawyers."<sup>60</sup> On the other hand, Commander Doolin, being from a naval background, takes a more operational approach. After stating that the existing legal framework does not justify probable cause to stop motor vessels on the high seas solely based on "what they are suspected of transporting," he promotes the concept of

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<sup>53</sup> Cesaretti, "Combating terrorism in the Mediterranean."

<sup>54</sup> Hammick, "Navies endeavour to police the Mediterranean Sea."

<sup>55</sup> NATO Briefing, "Combating Terrorism at sea," *NATO E-Bookshop* (July 2006), 3, [http://www.nato.int/ebookshop/briefing/active\\_endeavour/active\\_endeavour2008-e.pdf](http://www.nato.int/ebookshop/briefing/active_endeavour/active_endeavour2008-e.pdf).

<sup>56</sup> Doolin, "The Proliferation Security Initiative: Cornerstone of a New International Norm," 29.

<sup>57</sup> Cesaretti, "Combating terrorism in the Mediterranean."

<sup>58</sup> Ibid.; U.S. Department of State. Proliferation Security Initiative, "Statement of Interdiction Principles," <http://www.state.gov/t/isn/rls/fs/23764.htm>.

<sup>59</sup> Shulman, "The Proliferation Security Initiative As A New Paradigm For Peace And Security," 35.

<sup>60</sup> Ibid., 39; Coceano, "The Proliferation Security Initiative: Challenges and Perceptions," 18-19.

“mastering the factors of space, force and time.”<sup>61</sup> This concept, in probable cause terms, calls for enhanced international intelligence gathering and sharing, and, though not going into technical details, for specially equipped “visit board search teams” (VBSST) to be used. The latter need, though not required for justifying boarding itself, is still relevant for establishing reasonable cause to seize the illicit material that may be hidden in the vastness of sealed containers and/or the ship’s compartments. Foremost, it implies the technical implications behind this special equipment, which are analogous to those discussed in this thesis.

Finally, Warden, in his thesis on overcoming challenges to the PSI, stresses the “challenge of detecting, identifying and characterizing WMD.”<sup>62</sup> In overcoming this challenge, he points out the significance of the research conducted by the Lawrence Livermore National Laboratory and potential cooperation with industry. Such cooperation is viewed as essential in developing radiation detection capabilities for use onboard intercepted vessels<sup>63</sup> and has already become a reality.<sup>64</sup>

Probable cause can further be promoted with the use of radiation portal monitors in a way similar to the existing concept of operations at several U.S. ports, as described by Kevin McCabe, chief inspector for Customs and Border Protection at the port of Newark, New Jersey.<sup>65</sup> Data from these monitors mounted on RHIBs and, potentially, on helicopters, should be “compared with the shipping manifest” as declared through the hailing procedure “in a process that usually takes only a few minutes”<sup>66</sup> and does not significantly interfere with the merchant vessel’s movement (only steady course and relatively low speed is required instead of a “dead stop” during boarding).

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<sup>61</sup> Doolin, “The Proliferation Security Initiative: Cornerstone of a New International Norm,” 38.

<sup>62</sup> Herbert N. Warden, “Overcoming Challenges to the Proliferation Security Initiative” (Master’s Thesis, NPS, September 2004), 70.

<sup>63</sup> Ibid., 76.

<sup>64</sup> Berkeley Nucleonics Corporation, “Radiation Portal,” Berkeley Nucleonics Corporation, <http://www.berkeleynucleonics.com/radiationportal.html>.

<sup>65</sup> White, “Detectors may Cause Port Delays.”

<sup>66</sup> Ibid.

In that direction, the much less controversial and less publicized Global Initiative to Combat Nuclear Terrorism may prove very constructive. According to Woolf, Kerr and Nikitin, although the Global Initiative to Combat Nuclear Terrorism faces constraints, such as lack of funding and consequent skepticism on behalf of U.S. Congress,<sup>67</sup> it nonetheless constitutes a “flexible framework” which can “prevent illicit trafficking by improving detection of such [nuclear] material.”<sup>68</sup> This framework also includes common exercises and sharing of doctrines, operational information, and technology in expert-level workshops.<sup>69</sup> This sharing of technology and expertise by scientists like Glenn F. Knoll,<sup>70</sup> in such fields as the properties of crystalline sodium iodide scintillators (the core of the gamma detectors used by ARAM), presents the potential of promoting probable cause for maritime interdiction operations involving illicit radioactive materials. While avoiding the “dangerous” path of “bending international law,”<sup>71</sup> the result of this cooperation should be, through credible and publicly available detection and identification data, achievement of the goal of reaching a global consensus on combating illicit nuclear trafficking at sea.

## **E. METHODS AND SOURCES**

Due to the interdisciplinary nature of this thesis, a range of different approaches and methods will be used. The core of the legal/political aspect will be approached with a combination of case study and comparative analysis. The current legal framework as expressed by the UNCLOS, the SUA Convention, and its 2005 Protocol of Amendment, as well as by UNSC resolutions, will set the basis for a case study of actual maritime exercises, such as the PSI “Adriatic Gate 2007” and NATO’s “Phoenix Express 2008,” and real-world maritime interdictions, including those of the *So San* and the *BBC China*

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<sup>67</sup> Amy F. Woolf et al., “Arms Control and Nonproliferation: A Catalog of Treaties and Agreements,” CRS Report for Congress, RL33865 (2008), 34, <http://www.fas.org/sgp/crs/nuke/RL33865.pdf>.

<sup>68</sup> Ibid.

<sup>69</sup> U.S. Department of State. Global Initiative to Combat Nuclear Terrorism, “Terms of Reference for Implementation and Assessment,” <http://www.state.gov/t/isn/rls/other/76421.htm>.

<sup>70</sup> Glenn F. Knoll, *Radiation Detection and Measurement* (New York: Wiley, 2000).

<sup>71</sup> Coceano, “The Proliferation Security Initiative: Challenges and Perceptions,” 15.

(described by U.S. officials as a successful interdiction under the PSI in October 2003<sup>72</sup>), to show probable cause implementation in the field. The potential legal alternatives will be assessed in the same way, using cases that may set a precedent for future maritime counter-proliferation invocation (M/V *Saiga* and M/V *Torrey Canyon* cases). Sources used are to be found in both official documents of the U.S. government and NATO, as well as in relevant critiques of existing scholarship.

Comparative analysis will evolve around the argument that the PSI is “an activity, not an organization,”<sup>73</sup> unlike NATO. This approach has certain drawbacks, such as the lack of standing assets,<sup>74</sup> but theoretically offers flexibility<sup>75</sup> and does not preclude any further cooperation with standing organizations, including NATO itself.<sup>76</sup>

To address the technical aspects of maritime interdiction of illicit nuclear material transportation, the ARAM system will be evaluated using the American National Standards Institute (ANSI) performance criteria for mobile and transportable radiation monitors employed for homeland security.<sup>77</sup> In this part of the ARAM maritime application, data collected both in the lab and in the field will be used to evaluate how distance from the source, relative speed of pass between sensor and target vessels, source type, shielding, and background radiation level/noise affect the critical aspects of detection and identification.

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<sup>72</sup> Song, “The U.S.-Led Proliferation Security Initiative and UNCLOS: Legality, Implementation, and an Assessment,” 121.

<sup>73</sup> Ibid., 105.

<sup>74</sup> “The PSI seeks to use existing authorities -- national and international -- to defeat proliferation.” See U.S. Department of State. Proliferation Security Initiative, “What is the Proliferation Security Initiative?” <http://www.state.gov/t/isn/rls/other/34726.htm>.

<sup>75</sup> Fabrice Pothier, “The Proliferation Security Initiative: Towards a New Anti-Proliferation Consensus?” *British American Security Information Council Research Report*, Occasional Papers on International Security Policy (2004), <http://www.basicint.org/pubs/Notes/BN041118.htm#05>.

<sup>76</sup> NATO Briefing, “Combating Terrorism at sea,” 3; Doolin, “The Proliferation Security Initiative: Cornerstone of a New International Norm,” 42-43.

<sup>77</sup> American National Standards Institute, Institute of Electrical and Electronics Engineers, and IEEE Xplore. *American National Standard Performance Criteria for Mobile and Transportable Radiation Monitors Used for Homeland Security* (New York, NY: Institute of Electrical and Electronics Engineers, 2006), <http://ieeexplore.ieee.org/servlet/opac?punumber=4197202>.

Finally, the thesis will offer findings and recommendations related to both political and technical aspects of dealing with the establishment of probable cause in maritime interdiction operations of illicit nuclear/radioactive materials.

## **F. THESIS OVERVIEW**

In order to set out a logical sequence, this thesis will follow the scheme of questions as set out in the Problems and Hypotheses section. The first question to be addressed is: “What constitutes illicit nuclear or radioactive material?” Next, the current legal framework as expressed by the UNCLOS, the SUA Convention and its 2005 Protocol of Amendment, as well as UNSC resolutions will be examined in order to answer the questions: “When does transporting nuclear or radioactive materials constitute an unlawful act, who constitutes proper authority to interdict the materials in question?” and “What is the legitimate breadth of this authority’s reach?” Shifting from theory to practice, existing approaches on how to justify probable cause by the PSI and NATO will be analyzed via exercises and interdictions undertaken so far, followed by another theoretical analysis of potential legal alternatives.

Next, the ARAM system will be examined as a specific technical approach to detection and identification of radioactive materials. This technology will be evaluated by thorough analysis of lab and field data towards the goal of potentially enhancing probable cause. Last, keeping in mind both legal and technical considerations, a final conclusion will be elaborated followed by feasible recommendations.

## II. EXISTING FRAMEWORK – FACTS, INTERPRETATION AND IMPLEMENTATION

### A. WHAT CONSTITUTES ILLICIT NUCLEAR OR OTHER RADIOACTIVE MATERIAL?

In order to answer this question, the potential threats posed by the materials in question must be identified. According to the International Atomic Energy Agency (IAEA), these “threats involve criminals or terrorists acquiring and using for malicious purposes:

- (a) nuclear explosive devices;
- (b) nuclear material to build an improvised nuclear explosive device (IND);
- (c) radioactive material to construct a radiological dispersal device (RDD); and/or
- (d) the dispersal of radioactivity through sabotage of installations in which nuclear and other radioactive material can be found or of such material in transport.”<sup>78</sup>

These potential threats cover a wide range of radioactive materials involved, which need to be further categorized. In terms of risk assessment, the IAEA makes at first the distinction between nuclear and other radioactive materials.<sup>79</sup> Materials categorized as “nuclear” are those which under certain conditions may be used for the fabrication of a nuclear explosive device, and are further divided into special fissile or source materials. The technical difference between them lies in the fact that special fissile materials are artificially processed, whereas source materials are naturally occurring. Hence plutonium-239 ( $^{239}\text{Pu}$ ) is a by-product of nuclear spent fuel, while the uranium isotope 235 ( $^{235}\text{U}$ ) must pass through an enrichment process in order to be upgraded to special fissile status. In contrast, source materials are comprised mainly of naturally occurring materials such as  $^{238}\text{U}$  and thorium-232 ( $^{232}\text{Th}$ ).<sup>80</sup>

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<sup>78</sup> IAEA, Combating illicit trafficking in nuclear and other radioactive material reference manual, 3.

<sup>79</sup> Ibid., 6.

<sup>80</sup> Ibid., 7.

Nuclear materials evidently present the highest threat to global security due to their ability to produce catastrophic nuclear explosions. Precisely because of this ability, very strict regulations have been imposed on their production and handling. In addition to the fact that the fissile core of a nuclear weapon is the most costly and difficult to acquire of its components, the whole assembly procedure of such a lethal device requires a sophisticated infrastructure and a very high level of expertise.<sup>81</sup> Nevertheless, the mere acknowledgement of such difficulties is not adequate to render the respective threat completely irrelevant. As Allen comments, the internationally accepted minimal requirement to produce a nuclear explosive device is, depending on the fissile material, 8 kg of plutonium or 25 kg of highly enriched uranium (HEU). Experts do not regard the prospect of a lower-yield weapon with as little as half that fissile mass as technically infeasible.<sup>82</sup> The prospect of a lower-yield device provides another possible avenue to potential proliferators or terrorists as they seek to overcome the obstacles represented by high-technology requirements, since – though unanticipated and problematic as it may seem – relevant plans have managed to escape the classified realm and become publicly available.<sup>83</sup> For this reason, a small quantity of illicit nuclear material, weighing just a few kilograms and the size of a baseball (given the extremely high density of such elements), poses an extremely high and real threat. In addition, as acknowledged by the IAEA, apart from ordinary nuclear explosive devices, special fissile materials may be also used for improvised ones. In this respect, HEU would, more likely than plutonium, be used for an IND, despite the fact that a greater quantity of HEU would be needed.<sup>84</sup> This last attribute makes HEU even more attractive for terrorists and increases the likelihood of its illicit trafficking.

At this point, it is important to note that the radiation detection capabilities of portal monitors should be complemented with identification capabilities for all the aforementioned special nuclear materials (SNMs), although not limited to them. As will

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<sup>81</sup> Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 19.

<sup>82</sup> Ibid.

<sup>83</sup> Ibid.

<sup>84</sup> Ibid.

be explained further in Chapter IV, portal monitors use spectroscopic identification techniques for gamma radiation. As scientific research has shown, “legal shipments of radioisotopes could be used to mask the presence of illicit nuclear materials.”<sup>85</sup> In addition to the performance limitations of the scintillators used, the presence of another source of gamma radiation may interfere with the identification algorithms of the monitor, thus masking co-existing special nuclear materials. More specifically, data indicates that the widely used industrial isotopes of cesium-137 (<sup>137</sup>Cs) and barium-133 (<sup>133</sup>Ba) can effectively mask “low detection levels of HEU and WGPu”<sup>86</sup> (weapons grade plutonium), respectively.

This points to a critical aspect of potentially illicit radioactive materials: their dual-use nature. SNMs can undoubtedly be used as either nuclear reactor fuel or as the fissile material for a nuclear explosive device. Therefore, given the strict regulatory controls to which these materials are subject, if intercepted without being properly registered to the ship’s manifest, they are automatically classified as illicit. This is not, however, the case for the wide range of other radioactive sources with widespread peaceful and commercially available applications, such as medicine and industry.<sup>87</sup> These materials, although not capable of sustaining a chain reaction (a prerequisite for producing a nuclear explosion) can be used in RDDs, commonly known as dirty bombs. In this case, no sophisticated techniques are required. Conventional explosives (such as TNT) or even non-explosive means can be used for the dissemination of radioactive particles over a dispersal area can be used, with a radius proportionate to the means.<sup>88</sup> Regarding this threat, though, there have been some exaggerated scenarios presented in the media. Official sources, among them Abel J. Gonzalez, director of the IAEA Division of Radiation and Waste Safety, estimate that civilian injuries and significant contamination “would be limited” and restricted to a small area, “possibly a few city

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<sup>85</sup> M.I. Reinhard, et al., “Detection of Illicit Nuclear Materials Masked with other Gamma-Ray Emitters,” *Nuclear Science Symposium Conference Record IEEE* 1 (October 29–November 1, 2006): 270–272.

<sup>86</sup> T. Saunders, “Spectroscopic portal identification of special nuclear materials,” *Nuclear Science Symposium Conference Record IEEE* 2 (October 26–November 3, 2007): 1209–1211.

<sup>87</sup> Gonzalez, “Security of Radioactive Sources: The Evolving New International Dimensions,” 41.

<sup>88</sup> IAEA, Combating illicit trafficking in nuclear and other radioactive material reference manual, 5.

blocks.”<sup>89</sup> Nevertheless, the effects of dirty bombs should not be neglected nor underestimated, since they would arguably inflict “much terror and psychological distress.”<sup>90</sup>

Therefore, shipments of medical or industrial isotopes should be regarded as potentially illicit and, if detected, should be thoroughly examined both in terms of regulatory control/manifestation, as well as physical storage: manifestation, in order to minimize the prospect of being used for criminal or unauthorized acts and physical storage, in order to uncover propensity to mask SNMs.

Last, naturally occurring radioactive material (NORM) such as potassium-40 ( $^{40}\text{K}$ ), which is largely used in agriculture as a fertilizer<sup>91</sup> and exists abundantly in a great variety of natural substances, such as bananas, or even the human body itself,<sup>92</sup> should not in any case be regarded as illicit radioactive material. For all of the reasons detailed above, the need for proper identification, in addition to detection, of all types of radioactive materials (SNM, medical, industrial, and NORM) is self-evident.

## **B. WHEN DOES TRANSPORTING NUCLEAR OR OTHER RADIOACTIVE MATERIALS CONSTITUTE AN UNLAWFUL ACT?**

Despite the profound effects on a global scale of the atomic bombardment in Hiroshima and Nagasaki, and the fear of a nuclear holocaust under which the world has lived since, there is still no clause in international law that explicitly bans the use of nuclear weapons in armed conflict<sup>93</sup> or renders their transport illicit. However, there have been several efforts to curtail the proliferation of nuclear weapons, mainly in the form of multinational treaties, such as the Nuclear Nonproliferation Treaty (NPT), which entered

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<sup>89</sup> Gonzalez, “Security of Radioactive Sources: The Evolving New International Dimensions,” 39.

<sup>90</sup> Ibid.

<sup>91</sup> Argonne National Laboratory, “Potassium-40,” Human Health Fact Sheet (August 2005), <http://www.ead.anl.gov/pub/doc/potassium.pdf>.

<sup>92</sup> Ibid.

<sup>93</sup> Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 18.

into force in 1970.<sup>94</sup> Under this treaty, which counts 189 state-parties (i.e., all recognized sovereign states with the exception of India, Pakistan, Israel, and North Korea), only the United States, Russia, France, China and the United Kingdom are entitled to produce and possess nuclear arms temporarily (until eventual nuclear disarmament occurs), with all other signatories agreeing to refrain from acquiring such arms forever. Moreover, under Article I of the NPT, these nuclear weapon states undertake “not to transfer to any recipient whatsoever nuclear weapons or other nuclear explosive devices or control over such weapons or explosive devices directly, or indirectly; and not in any way to assist, encourage, or induce any non-nuclear-weapon State to manufacture or otherwise acquire nuclear weapons or other nuclear explosive devices, or control over such weapons or explosive devices.”<sup>95</sup>

Therefore, under the existing framework, only the five officially recognized nuclear weapon states and the four non-party states to the NPT can legally transport nuclear weapons. Nonetheless, other substances including nuclear reactor fuel, as well as spent or reprocessed fuel also fall within the category of nuclear materials, but in this case they can be transported without onerous legal restrictions based on the inherent right of every state in peaceful or energy-related nuclear applications. (In the case of the non-nuclear weapon states party to the NPT, this would only require compliance with the safeguards provided for by Article III of the treaty in question and implemented by IAEA.)

The September 11, 2001, terrorist attacks, as well as North Korea’s withdrawal from the NPT on January 10, 2003,<sup>96</sup> pointed out two major weaknesses of the NPT: its failure to address provisions for non-state actors and its inferior binding force in relation to the rule of conventional or customary international law. In that direction and following an evolutionary process, a series of UNSC resolutions was passed. Resolution 1368 on September 12, 2001, came as a response to non-state actors’ terrorist threats and

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<sup>94</sup> United Nations, “Treaty on the Non-Proliferation of Nuclear Weapons,” Status of Multilateral Arms Regulation and Disarmament Agreements, <http://disarmament.un.org/TreatyStatus.nsf>.

<sup>95</sup> Ibid.

<sup>96</sup> Frederic L. Kirgis, “North Korea’s Withdrawal From The Nuclear Nonproliferation Treaty,” The American Society of International Law Insights (January 2003) <http://www.asil.org/insights/insigh96.htm>.

under it the UNSC decided “to remain seized of the matter.”<sup>97</sup> Resolution 1373 noted “with concern the close connection between international terrorism [...] and illegal movement of nuclear [...] and other potentially deadly materials, and in this regard emphasizes the need to enhance coordination of efforts on national, subregional, regional and international levels in order to strengthen a global response to this serious challenge and threat to international security.”<sup>98</sup> The climax came on April 28, 2004, with UNSC Resolution 1540, which was unanimously adopted and is binding on all states.<sup>99</sup> “*Recognizing* that most States have undertaken binding legal obligations under treaties to which they are parties,” and “*gravely concerned* by the threat of illicit trafficking in nuclear ... and related materials,” Resolution 1540 focuses attention on non-state actors. It urges all states to take prompt action toward preventing WMD proliferation as well as establishing strict domestic controls and legislation in that direction. Resolution 1540, though a significant step forward, limits itself to actions and jurisdiction that abide within the existing legal framework and is not intended to alter it. It falls short of recognizing as an offense the unlawful transportation of radioactive materials. It also depends on states to implement its decisions and does not provide any clause for “unilateral enforcement measures,”<sup>100</sup> such as maritime interdictions, in case of a state’s failure to comply.

This state-based authority for the implementation of the relevant treaties and regulations regarding radioactive materials is not only limited to the territorial landmass, waters, and airspace, but also all vessels sailing on the high seas under a state’s flag. Thus, the case of a vessel at sea while engaged in illicit trafficking of radioactive materials, raises the issue of who holds proper criminal jurisdiction over her and her cargo.

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<sup>97</sup> United Nations, “United Nations Security Council Resolution 1368,” 2001, <http://daccessdds.un.org/doc/UNDOC/GEN/N01/533/82/PDF/N0153382.pdf?OpenElement>.

<sup>98</sup> U.S. Department of State, “United Nations Security Council Resolution 1373,” U.S. Department of State (September 28, 2001), [http://www.un.org/Docs/sc/unsc\\_resolutions04.html](http://www.un.org/Docs/sc/unsc_resolutions04.html).

<sup>99</sup> Article 25 of the UN Charter.

<sup>100</sup> Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 45.

### **C. WHO CONSTITUTES PROPER AUTHORITY TO INTERDICT THE MATERIALS IN QUESTION? WHAT IS THE LEGITIMATE REACH OF THIS AUTHORITY?**

In attempting to answer these questions, Devon Chaffee's observation that "there is nothing in the LOS that explicitly prohibits transit of WMD or gives states rights to interdict such transit" serves as a useful starting point.<sup>101</sup> However, a more accurate answer requires closer consideration of three factors: the cargo type of the interdicted ship, the maritime zone of the interdiction, and the flag under which the vessels in question sails.<sup>102</sup>

UNCLOS divides the seas into several maritime zones, in which issues of jurisdiction generally comply with the following empirical rule: their complexity index is directly proportional to the distance from the coastline.<sup>103</sup> The first one of these zones is made up of internal waters (i.e. ports, mouths of rivers and small bays). Any coastal state enjoys full and absolute jurisdiction within its internal waters. Thus, it has the right to stop, board, and search any vessel, regardless of flag of registration, and even proceed to the seizure of any illicit radioactive materials found. In this case, probable cause criteria do not fall under the law of the sea, but under a state's own national legislation.<sup>104</sup>

Further away from the coast, the seas are demarcated into territorial waters, contiguous waters, exclusive economic zones, and the high seas, as shown in Figures 1 and 2 (NM standing for nautical miles).

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<sup>101</sup> Devon Chaffee, "Freedom or Force on the High Seas? Arms Interdiction and International Law," Nuclear Age Peace Foundation (August 15, 2003), [http://www.wagingpeace.org/articles/2003/08/15\\_chaffee\\_freedom-of-force.htm](http://www.wagingpeace.org/articles/2003/08/15_chaffee_freedom-of-force.htm).

<sup>102</sup> Song, "The U.S.-Led Proliferation Security Initiative and UNCLOS: Legality, Implementation, and an Assessment," 113-114.

<sup>103</sup> Persbo and Davis, "Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea," 6.

<sup>104</sup> Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 110-111.

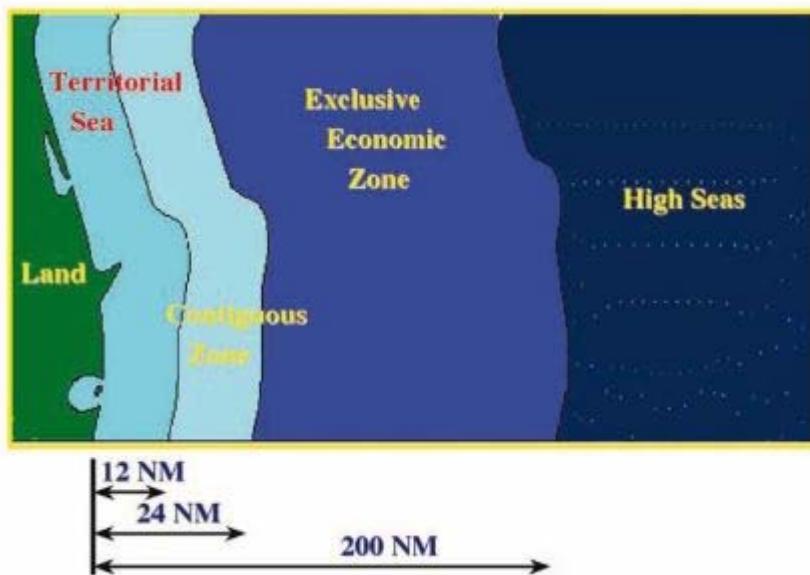


Figure 1. Maritime Zones.<sup>105</sup>

Within its territorial waters, a coastal state still exercises its sovereignty rights, although its jurisdiction is somewhat limited due to the right of innocent passage given to foreign-flagged vessels. The right of innocent passage is recognized by all states, coastal or land-locked, by both conventional<sup>106</sup> and customary law;<sup>107</sup> thus adherence to it is required for both signatories and non-signatories of the UNCLOS. In order for this rule to apply, the passage must be “continuous and expeditious,”<sup>108</sup> in addition to not being “prejudicial to the peace, good order or security of the coastal state.”<sup>109</sup> Moreover, Article 23 of UNCLOS provides further amplification for the case of “ships carrying nuclear or other inherently dangerous or noxious substances,” stating that they should “carry documents and observe special precautionary measures established for such ships by

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<sup>105</sup> Source: Royal Australian Navy. “The Navy Contribution to Australian Maritime Operations: RAN Doctrine 2 – 2005.” Royal Australian Navy Publications (June 21, 2005) [http://www.navy.gov.au/w/images/NCAMO\\_Book.pdf](http://www.navy.gov.au/w/images/NCAMO_Book.pdf).

<sup>106</sup> UNCLOS, Article 17.

<sup>107</sup> Persbo and Davis, “Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea,” 55.

<sup>108</sup> UNCLOS, Article 18.

<sup>109</sup> UNCLOS, Article 19.

international agreements” when exercising the right of innocent passage through the territorial sea. Thus, a literal application of the law of the sea leaves the coastal state with no legal standpoint to justify an interdiction of the suspected ship. Given also that the flag state’s exclusive jurisdiction cannot be exercised within the territorial waters of another state, the only appropriate course of action would be a boarding by the coastal state with the consent of the flag state.

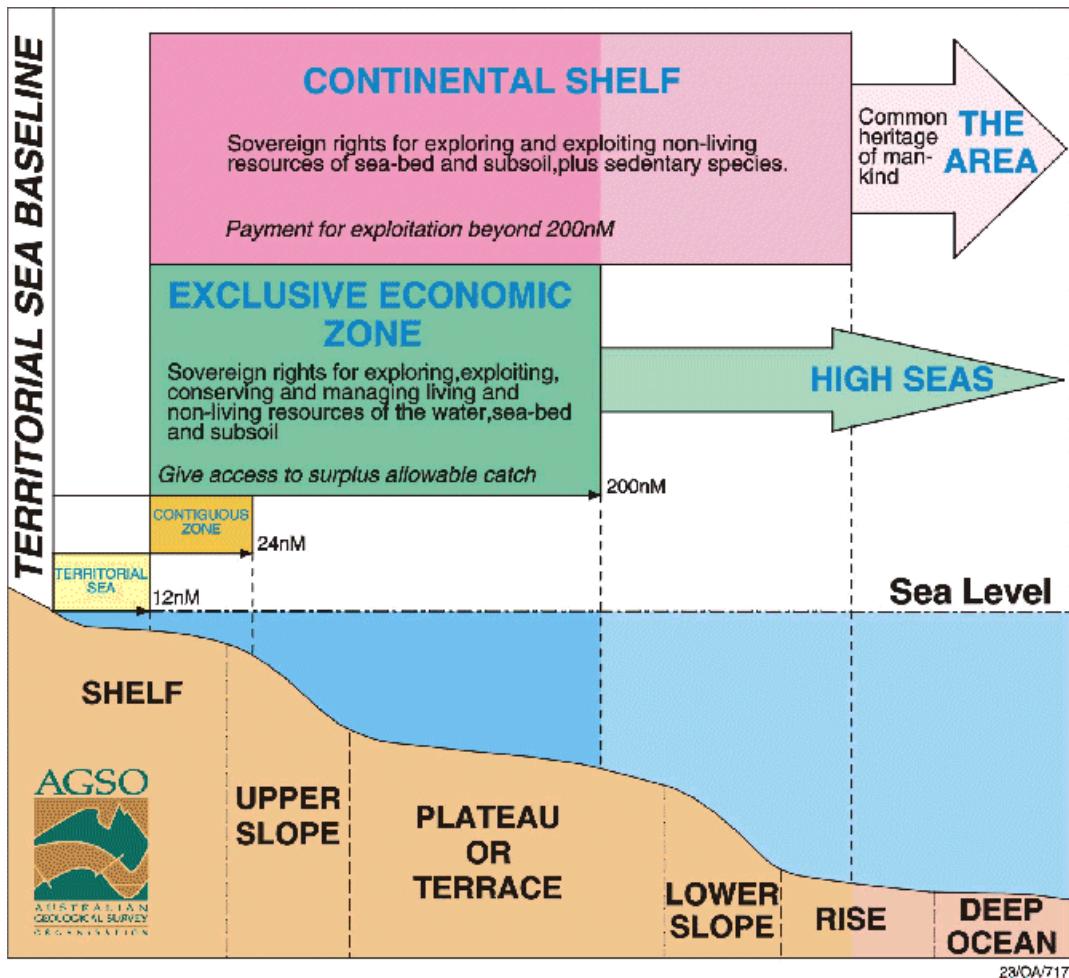


Figure 2. Side view of maritime zones with respect to ocean floor morphology.<sup>110</sup>

<sup>110</sup> Source: Frances B. Michaelis, “International Year of the Oceans-1998 Australia’s policies, programs and legislation,” Parliament of Australia, Parliamentary Library Research Paper 6 (December 8, 1998) <http://www.aph.gov.au/library/pubs/rp/1998-99/99rp06.htm>.

Nevertheless, among the specific preconditions described in Article 19 of UNCLOS, which would render a passage as non-innocent, is “any threat or use of force against the sovereignty, territorial integrity or political independence of the coastal State, or in any other manner in violation of the principles of international law embodied in the Charter of the United Nations.” This provision could provide grounds for a coastal state to interdict a passing foreign-flagged vessel transporting radioactive materials, based on the claim that such passage is not innocent. This argument could be further supported by Article 21 and a “liberal interpretation”<sup>111</sup> of Article 25. Article 21 specifically grants a coastal state the right to adopt laws and regulations applying to vessels conducting innocent passage and regarding the “prevention of infringement of the customs, fiscal, immigration or sanitary laws and regulations of the coastal State,” while under Article 25, the coastal state may “suspend temporarily in specified areas of its territorial sea the innocent passage of foreign ships if such suspension is essential for the protection of its security.” Clearly, there is still a substantial degree of controversy regarding interdiction of illicit radioactive materials being transported through territorial waters, with both sides having credible arguments to support their case.

The right of innocent passage can be viewed merely as a component of the freedom of navigation, which is the governing principle of the oceans: the more distant from shore, the more difficult it becomes to contest this principle for conducting maritime interdiction operations. The semantic differential between territorial waters and the rest of the maritime zones that extend beyond it is that the latter ensemble is regarded, in purely navigational terms, as international waters.<sup>112</sup> According to Article 31 of UNCLOS, in the adjacent-to-the-territorial sea contiguous zone, the coastal state may only exercise the control necessary to “prevent infringement of its customs, fiscal, immigration or sanitary laws and regulations within its territory or territorial sea” or to “punish infringement of the above laws and regulations committed within its territory or territorial sea.” More simply put, any foreign-flagged vessel merely transiting through a coastal state’s

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<sup>111</sup> Song, “The U.S.-Led Proliferation Security Initiative and UNCLOS: Legality, Implementation, and an Assessment,” 117.

<sup>112</sup> *Ibid.*

contiguous zone may not be interdicted by that or any other state (except the one under which it is registered), regardless of the nature of her cargo. Customs laws and other regulations may provide a qualifying reason for boarding only if the vessel in question has just left or intends to enter the territorial waters of the coastal state.

However, under Article 56 of UNCLOS, the coastal state enjoys within its exclusive economic zone sovereign rights only for the “purpose of exploring and exploiting, conserving and managing [...] natural resources.” Under the same article, in exercising these rights the coastal state shall “have due regard to the rights and duties of other States and shall act in a manner compatible with the provisions of this Convention.” Once more, the most prominent of the rights that other states enjoy is that established under Article 87, the right of freedom of navigation. Unless a vessel transporting radioactive materials acts in infringement of environmental protection laws, any potential interdiction would constitute a disruption of legitimate shipping. In other words, the exclusive economic zone is intended to ensure the coastal state’s rights in exploiting its adjacent oceans and not in any case policing them.

Last, the high seas encompass the whole body of the oceans that lie beyond all previously mentioned maritime zones. The high seas are open to all states, whether coastal or land-locked,<sup>113</sup> and no state enjoys any form of sovereign rights.<sup>114</sup> Most important, ships sailing on the high seas are subject to the exclusive jurisdiction of the flag state, “save in exceptional cases.”<sup>115</sup> These cases are exhaustively described in Article 110 under the right of visit, or simply put, the right to board a vessel. Hence, boarding on the high seas is legally justified if, and only if, there is “reasonable ground for suspecting that:

- (a) the ship is engaged in piracy;
- (b) the ship is engaged in the slave trade;
- (c) the ship is engaged in unauthorized broadcasting and the flag State of the warship has jurisdiction under article 109;

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<sup>113</sup> UNCLOS, Article 87.

<sup>114</sup> UNCLOS, Article 89.

<sup>115</sup> UNCLOS, Article 92.

- (d) the ship is without nationality; or
- (e) though flying a foreign flag or refusing to show its flag, the ship is, in reality, of the same nationality as the warship.”<sup>116</sup>

Despite the fact that Article 110 does not grant states the *de jure* right of combating nuclear proliferation on the high seas similar to the already-vested right of combating piracy, it still presents some ground for interdicting radioactive materials, which are limited to cases of stateless or dubious nationality vessels or environmental safety violations. In these cases, as in any of the aforementioned issues regarding the territorial, contiguous, or exclusive economic zones, though the legal status of any pretence used will remain ambivalent and an issue of dispute by concerned parties, what needs to be established at first is reasonable ground for suspecting an illicit activity, in other words, probable cause.

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<sup>116</sup> UNCLOS, Article 110.

### **III. HOW TO JUSTIFY PROBABLE CAUSE? EXISTING APPROACHES AND POTENTIAL ALTERNATIVES**

#### **A. EXISTING APPROACHES (PEACETIME RIGHT OF APPROACH AND VISIT – CONSENT OF THE FLAG NATION)**

##### **1. Proliferation Security Initiative (PSI)**

###### *a. Origins*

The PSI is a U.S.-led initiative announced by President Bush during a speech in Poland in May 2003, just before the G-8 summit. Along with the general concern for promoting the non-proliferation regime, the PSI was largely intended to counter a “weakness” in international law that was exposed by an incident in December 2002. After an intelligence tip by U.S. services that had classified a vessel as suspect, the Spanish authorities had seized 15 Scud missiles that had been found onboard the *So San*, a North Korean freighter. What would have been a great non-proliferation success ended up as a fiasco since the Spanish authorities did not have the “*de jure*” right to confiscate the cargo nor to detain the transporting ship, which was eventually released.<sup>117</sup> In a speech announcing the PSI, President Bush said, “when weapons of mass destruction or their components are in transit, we must have the means and authority to seize them,” a statement very likely to have been inspired by this incident.<sup>118</sup> Moreover, despite the fact that UNSC Resolution 1540, calling on all states to take cooperative action to prevent trafficking in WMD, was passed almost a year after the announcement of the PSI, it is officially regarded by the U.S. as “a positive way to take such cooperative action.”<sup>119</sup>

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<sup>117</sup> Song, “The U.S.-Led Proliferation Security Initiative and UNCLOS: Legality, Implementation, and an Assessment,” 104.

<sup>118</sup> Ibid.

<sup>119</sup> U.S. Department of State, “What is the Proliferation Security Initiative?” U.S. Department of State, <http://www.state.gov/t/isn/rls/other/34726.htm>.

***b. Statement of Interdiction Principles***

What is more important, though, is that the PSI identifies interdiction as a focal point of its strategy.<sup>120</sup> Hence, the core of the initiative lies in the Statement of Interdiction Principles, adopted in the third PSI meeting, held in Paris, on September 4, 2003. Prior to the principles themselves, three facts/claims need to be pointed out in the respective text: the first is that PSI supports previous efforts of international community in countering WMD proliferation, “including existing treaties and regimes.”<sup>121</sup> Second, the PSI is intended to permit the interdiction of WMD and related materials “flowing to or from states and non-state actors of proliferation concern.” Third, such interdictions will be “consistent with national legal authorities and relevant international law and frameworks.” As for the principles themselves, they can be summarized as calling on participating and all other concerned states to:

- (i) interdict WMD and related materials being transported to and from states and non-state actors of proliferation concern
- (ii) adopt streamlined procedures for sharing information about relevant trafficking
- (iii) strengthen national legal authority in order to accomplish the aforementioned goals, as well as working with other states to also strengthen relevant international law and frameworks
- (iv) take specific actions in support of the interdiction in question and consistent to national and international laws.<sup>122</sup>

Apart from making use of their peacetime right to approach and visit, Principle IV relates specifically to partners making use of flag-state exclusive jurisdiction in their internal/territorial waters and on the high seas, as well as providing consent “under the appropriate circumstances to the boarding and searching of its own flag vessels by other states.”<sup>123</sup>

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<sup>120</sup> U.S. Department of State, “The Proliferation Security Initiative (PSI),” U.S. Department of State, <http://www.state.gov/t/isn/rls/fs/105217.htm>.

<sup>121</sup> U.S. Department of State. Proliferation Security Initiative, “Statement of Interdiction Principles,” U.S. Department of State, <http://www.state.gov/t/isn/rls/fs/23764.htm>.

<sup>122</sup> Ibid.

<sup>123</sup> Ibid.

It is understood that the PSI does not impose any formal obligations on participating states.<sup>124</sup> In the words of the chairman of the second meeting, held in Brisbane, Australia, it reflects “collective political commitment,”<sup>125</sup> empowered in the field of maritime interdictions by the embodiment of its participating states’ sovereign rights.<sup>126</sup>

*c. Bilateral Ship-Boarding Agreements*

When sovereign rights are not sufficient to justify the right of visit under the preconditions of the law of the sea, the consent of the flag state, whether a PSI participant or not, must be sought to provide proper legal cause. In this context, and in order to facilitate or accelerate the whole process of granting consent,<sup>127</sup> the U.S., as the leading PSI partner, has initiated the practice of signing bilateral ship-boarding agreements, especially with leading nations in terms of their ships’ registries. Despite the fact that as few as six core PSI partners make up for almost 12 percent of the global ships registry,<sup>128</sup> this figure is still unacceptable in risk management terms, since even one vessel transporting illicit radioactive materials can inflict significant casualties and damage. Thus, in order to increase the odds of successfully interdicting these materials,

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<sup>124</sup> U.S. Department of State, “Proliferation Security Initiative,” USINFO Publications, <http://usinfo.state.gov/products/pubs/proliferation/>.

<sup>125</sup> Australian Government, Department of Foreign Affairs and Trade, “Proliferation Security Initiative, Brisbane Meeting, 9-10 July 2003, Chairman Statement,” Australian Government, Department of Foreign Affairs and Trade, [http://www.dfat.gov.au/globalissues/psi/chair\\_statement\\_0603.html](http://www.dfat.gov.au/globalissues/psi/chair_statement_0603.html).

<sup>126</sup> Doolin, “The Proliferation Security Initiative: Cornerstone of a New International Norm,” 34.

<sup>127</sup> The existence or not of rapid procedures for carrying out a consensual boarding may prove to be crucial, especially when the suspect vessel sails in the vicinity of a coastal state not espousing PSI principles or, in an even worse-case scenario, its final destination is a state about which there are proliferation concerns. In such a case, a significant delay in according consent might render the whole procedure irrelevant, since even a consensual boarding cannot be carried out in a third country’s territorial waters.

<sup>128</sup> Doolin, “The Proliferation Security Initiative: Cornerstone of a New International Norm,” 36.

the U.S. has signed bilateral agreements with Belize, Croatia, Cyprus, Liberia, Malta, Marshall Islands, Mongolia and Panama,<sup>129</sup> which add up to the accessible shipments of more than 60 percent of the world's tonnage.<sup>130</sup>

*d. Intelligence*

In the new security environment that emerged after the September 11, 2001, attacks, intelligence has been correctly acknowledged as the “first line of defense.”<sup>131</sup> A series of specific reasons make intelligence indispensable to maritime interdiction operations, not only limited to the aforementioned vastness of the oceans. First of all, especially during the early years of the initiative, there was an inadequate maritime surveillance infrastructure to deal with new developments. Based on Cold War standards intended only to monitor the relatively small number of an adversary’s warships, ocean surveillance lagged behind in terms of similarly monitoring the large number of commercial vessels at sea.<sup>132</sup> Additional considerations which make surveillance of commercial shipping even more substantially difficult, also included the owner of the vessel, her cargo, and most importantly, the consigner and the recipient of that cargo. Given the dual-use nature of radioactive materials, the actual and not the “declared” origin and destination of such cargo needed to be known, in order for them to be properly identified with states or non-state actors of proliferation concern. Considering further the notion of illicit radioactive materials being transported while undeclared in a ship’s manifest, intelligence became even more crucial. Even today, it is not an uncommon practice for ships to sail without a predetermined recipient of their cargo; for

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<sup>129</sup> U.S. Department of State. Proliferation Security Initiative, “Ship Boarding Agreements,” U.S. Department of State, <http://www.state.gov/t/isn/c12386.htm>.

<sup>130</sup> Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 53.

<sup>131</sup> The White House, “President’s Statement on the Intelligence Reform and Terrorism Prevention Act of 2004,” The White House, <http://www.whitehouse.gov/news/releases/2004/12/20041208-11.html>.

<sup>132</sup> John Pike, Global Security Director. See Global Security, “Terror Lurks on the High Seas,” Global Security (September 21, 2003), <http://www.globalsecurity.org/org/news/2003/030921-terror1.htm>.

tankers in particular, their cargo can change ownership while in transit up to seven times.<sup>133</sup> This being the case, without an allocated shadowing unit for each vessel, it becomes virtually impossible to keep accurate track of commercial shipping.

For all these reasons, intelligence has been identified by PSI as a primary means of classifying vessels as “reasonably suspected of carrying [WMD] cargoes” and the adoption of streamlined procedures for intelligence exchange as one of PSI’s formally enumerated interdiction principles.<sup>134</sup> Nevertheless, overreliance on intelligence or using poor intelligence for establishing probable cause in maritime interdictions can also be counterproductive. As Allen points out, “intrusive interdictions based on intelligence that ultimately proves faulty will tend to erode public confidence in the program [PSI] and may shake the resolve of other PSI participating states.”<sup>135</sup> Moreover, intelligence, regardless of source (HUMINT, SIGINT, or IMINT),<sup>136</sup> is not only limited by data-gathering considerations, but also by inherent restrictions for sharing it. Keeping in mind that even within NATO, a treaty-based, long-lived, and consolidated alliance, intelligence sharing is conducted “on a limited, selective basis,” mostly in the form of “processed intelligence, rather than raw data.”<sup>137</sup> It is evident that in such a loosely connected “activity” as the PSI an even greater reluctance to share relevant information would apply.

#### *e. Exercises*

Beyond issues related to credible information gathering and sharing, another concern is the need for the integration of this intelligence with the command, control and communications structures of the PSI participants, and afterwards, to test this

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<sup>133</sup> Persbo and Davis, “Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea,” 37.

<sup>134</sup> U.S. Department of State. Proliferation Security Initiative, “Statement of Interdiction Principles,” U.S. Department of State, <http://www.state.gov/t/isn/rls/fs/23764.htm>.

<sup>135</sup> Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 60.

<sup>136</sup> Standing respectively for human, signal and imagery intelligence.

<sup>137</sup> Tomas Valasek, “NATO’s New Roles: A Vision From Inside The Alliance,” Center for Defense Information (CDI) (October 19, 2001), <http://www.cdi.org/terrorism/nato.cfm>.

integration.<sup>138</sup> Until now, at least 30 exercises have been conducted on a worldwide scale (involving more than 70 nations) by PSI member states,<sup>139</sup> most of them in a maritime environment,<sup>140</sup> which appears to be the initiative's focus since its conception. Table 1 summarizes these PSI exercises.

Participation in exercises is not limited to the military and may also include assets from the coast guard and other related law enforcement agencies such as the customs or intelligence services. Neither are these exercises bound by the geographic context posed by the sovereign limits of the host nation. They are usually multinational in nature and include the active participation of several countries, whether contiguous or not, and are observed by the representatives of many others.<sup>141</sup> The goal of these exercises is to "increase interoperability, improve interdiction decision-making processes, and enhance the interdiction capacities and readiness of all participating states."<sup>142</sup> Clearly, probable cause is one of the key issues addressed by these PSI exercises, since both reason/evidence of suspicion and legality under UNCLOS lie within the framework set by "interdiction decision-making processes." Probable cause is further enhanced by the PSI Operational Experts Group (OEG), drawing from across the spectrum of involved fields (military, law enforcement, intelligence, legal, and diplomatic). During their meetings, participants strive to "develop operational concepts, organize the interdiction exercise program, share information about national legal authorities, and pursue cooperation with key industry sectors."<sup>143</sup>

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<sup>138</sup> Persbo and Davis, "Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea," 39.

<sup>139</sup> U.S. Department of State, "The Proliferation Security Initiative (PSI)," U.S. Department of State, <http://www.state.gov/t/isn/rls/fs/105217.htm>.

<sup>140</sup> Song, "The U.S.-Led Proliferation Security Initiative and UNCLOS: Legality, Implementation, and an Assessment," 107-109.

<sup>141</sup> Song, "The U.S.-Led Proliferation Security Initiative and UNCLOS: Legality, Implementation, and an Assessment," 107-109.

<sup>142</sup> U.S. Department of State, "The Proliferation Security Initiative (PSI)," U.S. Department of State, <http://www.state.gov/t/isn/rls/fs/105217.htm>.

<sup>143</sup> Ibid.

Table 1. Proliferation Security Initiative Maritime Interdiction Exercises

Sept. 10-13, 2003	Exercise PACIFIC PROTECTOR: Australian-led maritime exercise conducted in the Coral Sea.
Oct. 13-17, 2003	Exercise SANSO '03: Spanish-led maritime exercise conducted in the Western Mediterranean.
Nov. 25-27, 2003	Exercise BASILIC '03: French-led maritime exercise conducted in the Western Mediterranean.
Jan. 11-17, 2004	Exercise SEA SABER: U.S.-led maritime exercise conducted in the Arabian Sea, United States.
Apr. 19-22, 2004	Exercise CLEVER SENTINEL: Italian-led maritime exercise conducted in the Mediterranean.
Oct. 25-27, 2004	Exercise TEAM SAMURAI '04: Japanese-led maritime interdiction exercise.
Nov. 8-18, 2004	Exercise CHOKEPOINT '04: U.S.-led maritime interdiction exercise.
Apr. 8-15, 2005	Exercise NINFA '05: Portuguese-led maritime/ground interdiction exercise.
Aug. 15-19, 2005	Exercise DEEP SABRE: Singaporean-led maritime/ground interdiction exercise.
Nov. 14-19, 2005	Exercise EXPLORING THEMIS: UK-hosted maritime/Command Post Exercise (CPX) <sup>144</sup> interdiction exercise.
Apr. 4-5, 2006	Exercise TOP PORT: Dutch-hosted maritime / CPX interdiction exercise.
May 24-26, 2006	Exercise ANATOLIAN SUN: Turkish-hosted combined air, land and sea CPX and LIVEX interdiction exercise.
Sept. 13-15, 2006	Exercise AMBER SUNRISE: Polish-hosted maritime/ground exercise with participation by Denmark, Russia, and Sweden.
Oct. 10-31, 2006	Exercise LEADING EDGE: U.S.-hosted CPX and maritime/ground interdiction exercise (Persian Gulf).
May 27-29, 2007	Exercise ADRIATIC GATE: Slovenian-hosted ground/port interdiction exercise.
June 18-22, 2007	PSI Gaming Exercise: U.S.-hosted exercise at the Naval War College, Newport, Rhode Island.
Aug. 29-Sept. 7, 2007	Exercise PANAMAX 07: U.S.-hosted maritime PSI scenario.
Oct. 12-15, 2007	Exercise Pacific Shield 07: Japanese-hosted PSI maritime/port interdiction exercise.
Oct. 29-31, 2007	Exercise Eastern Shield 07: Ukrainian-hosted combined air, ground, and sea interdiction exercise with participation from Bulgaria, Romania, Georgia, Moldova, and Poland.
Mar. 10-12, 2008	Exercise Guistir 08: Djiboutian- and French-hosted maritime / port interdiction exercise (Key participants: Red Sea and Maghreb countries.)
Apr. 8-22, 2008	Exercise Phoenix Express 08: U.S.-led maritime interoperability exercise in the Mediterranean Sea. Maritime interdiction PSI scenario included.
May 12-14, 2008	Exercise Adriatic Shield 08: Croatian-hosted maritime / port interdiction exercise. (Key participants: Adriatic Sea countries, Poland, and the U.S.)
Source: "Calendar of Events," U.S. State Department, <a href="http://www.state.gov/t/isn/c12684.htm">http://www.state.gov/t/isn/c12684.htm</a> , last accessed August 1, 2008.	

<sup>144</sup> "CPX command post exercise: An exercise in which the forces are simulated, involving the commander, his staff, and communications within and between participating headquarters." See Federation of American Scientists (FAS) Military Analysis Network, "Types of Exercises," Federation of American Scientists, [http://www.fas.org/programs/ssp/man/usmillogistics/military\\_exercises.html](http://www.fas.org/programs/ssp/man/usmillogistics/military_exercises.html).

Two of the most recent PSI maritime exercises were “Adriatic Gate 2007” and “Pacific Shield 07,” hosted by Slovenia and Japan, respectively. In the first, the concept of operations consisted of “stopping, searching and securing of container with ‘dirty bomb’-related materials in the port of Koper.”<sup>145</sup> Apart from the hosting nation and observers from 40 different countries,<sup>146</sup> participants included Bosnia and Herzegovina, Montenegro, Croatia, and the U.S., the latter providing expertise on the detection of materials in question.

On the other hand, “Pacific Shield 07” involved ten vessels and four aircraft from Australia, France, Britain, New Zealand, Japan, Singapore, and the United States training in the interdiction of vessels transporting WMD-related materials both in port and at sea. More specifically, the series of events included search, detection, and tracking the suspect vessel at sea, boarding procedures, on-board search and detection of WMD-related materials, as well as in-port cargo inspection.<sup>147</sup>

These scenarios, taking place in the internal waters of a PSI participant, support the claim that PSI activities are in compliance with international and national legal requirements,<sup>148</sup> while the at-sea boardings demonstrate to potential traffickers both readiness and resolve to proceed in high seas interdictions, when UNCLOS requirements are fulfilled.

#### *f. Maritime Interdictions*

No matter how sophisticated the exercises, or how useful the operational doctrines they produce, the very word ‘scenario’ implies parameters that are controllable to a large extent. Thus, such exercises are nearly always “successful” in ways that cannot be disputed.

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<sup>145</sup> Ministry of Foreign Affairs of the Republic of Poland, “Adriatic Gate 2007,” Cracow Proliferation Security Initiative, Exercises, <http://www.land.polemb.net/index.php?document=101>.

<sup>146</sup> James Martin Center for Nonproliferation Studies (CNS), “Proliferation Security Initiative (PSI),” CNS Publications, <http://cns.miis.edu/inventory/pdfs/psi.pdf>.

<sup>147</sup> Ibid.; The Ministry of Foreign Affairs of Japan, “PSI Maritime Interdiction Exercise Pacific Shield 07,” The Ministry of Foreign Affairs of Japan, <http://www.mofa.go.jp/policy/UN/disarmament/arms/psi/overview0710.html>.

<sup>148</sup> Jacquelyn S. Porth, “U.S. Security Initiative Draws More Participants,” U.S. Embassy in Seoul, (May 31, 2007) [http://seoul.usembassy.gov/410\\_053107.html](http://seoul.usembassy.gov/410_053107.html).

On the other hand, real world interdiction operations and their results are rarely publicized, due to the delicate and usually classified nature of the intelligence/operational information involved. It is true, though, that some of them have been carried out since 2003, as the engineer behind the PSI and then-U.S. Under-Secretary of State for Arms Control and International Security John R. Bolton has acknowledged.<sup>149</sup> The most prominent PSI interdiction cited by U.S. officials as being successful was the *BBC China* incident of October 2003.<sup>150</sup> The vessel was flying a German flag and was owned by a German shipping company. Its last port of call was Dubai and its declared destination was a Libyan port;; it was sailing in the Red Sea carrying as part of its cargo centrifuge equipment: i.e., nuclear weapons-related technology for the uranium enrichment process. This information had come to the knowledge of U.S. and UK intelligence services and, as part of PSI intelligence sharing, was made available to German authorities. The latter, through the ship-owner, ordered the ship to divert to Taranto, Italy immediately after it entered the Mediterranean Sea through the Suez Canal. There, it was thoroughly searched by Italian authorities, who seized the five containers of the illegal cargo (not declared in the ship's manifest).<sup>151</sup> Despite the fact that this incident did not directly involve radioactive materials, it included every other aspect of a successful and legitimate probable cause establishment, and subsequent interdiction. Reason for suspicion was established by what proved to be credible intelligence. Since the ship was sailing on the high seas, legitimacy of action was sought through the consent of the flag state and, as soon as the latter was granted, interdiction took place in the internal waters of a PSI state, where existing national legislation and manifest improprieties classified the cargo as illicit, and therefore subject to confiscation.

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<sup>149</sup> Persbo and Davis, “Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea,” 68.

<sup>150</sup> Nevertheless, it should be noted that the *BBC China* incident “has also been criticized as being a false claim of success for the Proliferation Security Initiative.” See “False Claims of PSI Success,” *The Washington Times*, August 17, 2005, as cited in Song, “The U.S.-Led Proliferation Security Initiative and UNCLOS: Legality, Implementation, and an Assessment,” 121.

<sup>151</sup> Persbo and Davis, “Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea,” 62; Song, “The U.S.-Led Proliferation Security Initiative and UNCLOS: Legality, Implementation, and an Assessment,” 121.

Also noteworthy is the *So San* incident of December 9, 2002, before the establishment of the PSI. Again, the suspect cargo did not include radioactive materials, but instead Scud missiles. Nevertheless, in terms of the legal framework, the same conditions apply and clearly demonstrate the strict context that the law of the sea pertains to the right of approach and visit on the high seas. Initial suspicion was provided by intelligence (money transfers and satellite imagery), but was further complemented by surveillance provided by the Spanish frigates *Patino* and *Navarra*, patrolling the Arabian Gulf, as part of Operation Enduring Freedom.<sup>152</sup> The ship had left the North Korean port of Nampo, heading to Yemen. Adding to initial suspicions, surveillance indicated that the vessel was following a zig-zag course, and most importantly, kept lowering and raising its flag.<sup>153</sup> Whereas the first factor merely indicates unusual conduct (since commercial ships typically follow a fixed track corresponding to the shortest route), the second is a violation of UNCLOS Article 92,<sup>154</sup> giving reasonable grounds to suspect that the vessel was without nationality. Hence the right of approach and visit as described under UNCLOS Article 110 could be invoked.

Under the customary law of the sea, implementation of the right of approach and visit includes several discrete phases. First, the warship establishes communication with the suspect vessel and requests identification data, including its name, flag, port of registry, cargo, and last and next port of call. If the provided data cannot be verified, the warship has the right of investigation: i.e., to send an officer-led team to inspect the official documents of the merchant ship or to order the ship's master to have these documents presented aboard the warship. If there is any remaining suspicion, the warship has the right to board and search the vessel. The last phase, coinciding with the right of seizure, is only applicable if the findings of the search provide evidence that the vessel is actually engaged in one of the illicit activities

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<sup>152</sup> Doolin, "The Proliferation Security Initiative: Cornerstone of a New International Norm," 29; and Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 150.

<sup>153</sup> Doolin, "The Proliferation Security Initiative: Cornerstone of a New International Norm," 29.

<sup>154</sup> This article states: "Ships shall sail under the flag of one State only and ... may not change flag during a voyage or while in a port of call, save in the case of a real transfer of ownership or change of registry."

encompassed under the law of the sea.<sup>155</sup> If this is not the case, and “suspicious prove to be unfounded, and provided that the ship boarded has not committed any act justifying them,” UNCLOS Article 110 provides that the ship “shall be compensated for any loss or damage that may have been sustained.”

In the case of *So San*, the above procedure was followed to the letter. During initial radio contact, the master claimed that his vessel was registered under Cambodian flag and was transporting cement to Yemen. Communication with the Cambodian authorities disproved this claim, so the *Navarra* proceeded to the boarding and search of the vessel. The search revealed 15 Scud missiles that the North Korean government had sold to its Yemeni counterpart, and which were not declared in the ship’s manifest. As is the case with radioactive materials, the transport of missiles between states does not constitute an illicit act on the high seas and right of seizure could not be implemented; the *So San* was eventually allowed to proceed to its destination.<sup>156</sup> Probable cause for maritime interdiction had been lawfully established, but the existing framework fell short in justifying seizure.

## **2. NATO Operation Active Endeavour**

### *a. Origins*

The previous incidents, though excellent examples of interdictions, are not unique in recent maritime history, nor can PSI participants claim exclusiveness in conducting such operations. It has a NATO counterpart, namely “Operation Active Endeavour.” In the aftermath of the September 11, 2001, attacks, the United States called for the invocation of Article 5 of the North Atlantic Treaty, a request that was unanimously accepted by its allies. On October 4, 2001, the allies decided to take on eight initial measures, one of which involved the deployment of Standard Naval Force Mediterranean SNFM (now Standing NRF Maritime Group 2 (SNMG-2) “to provide a

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<sup>155</sup> Anastasia Strate, Maria Gavouneli, and Nikolaos Skourtos, *Unresolved Issues and New Challenges to the Law of the Sea: Time Before and Time After* (Leiden: Martinus Nijhoff Publishers, 2006), 155.

<sup>156</sup> Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 150-152; Persbo and Davis, “Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea,” 54-55.

deterrent presence and surveillance in strategic international waters at a key moment.”<sup>157</sup> The initial deployment of SNFM in Eastern Mediterranean was given the name “Operation Active Endeavour” (OAE) on October 16, 2001, and in the next months, provided valuable operational experience.

*b. Operations, Intelligence and Surveillance*

In due time however, Active Endeavour’s mission expanded, both in scope and geographic coverage. Initially the main task of NATO’s naval units was to “hail” merchant vessels transiting their patrolling areas (i.e., to call them on a VHF channel, ask questions about the ships’ identity, cargo, and activity, visually identify them, and monitor their movement for as long they were in sensor range). In other words, NATO’s activities were limited to the right of approach. This information was then related to CCMAR Naples, Italy and NATO’s shipping center in Northwood, UK. In April 2003 the mission was modified to include compliant boarding operations on suspect vessels, “compliant” in this case meaning with the prior consent of the ships’ masters and flag states, which gives the boarding full legitimacy under international law. In the case of a suspect classified M/V or of anything unusual or suspicious during the “hailing” procedure, the ship may be boarded to inspect documentation and cargo under the new doctrine, but only if “it is the most sensible course of action.”<sup>158</sup> Otherwise, the ship is “shadowed until action is taken by a responsible agency”<sup>159</sup> or it reaches a country’s territorial waters where the authorities of the next port of call are asked to inspect it. In the case that consent is not given for a compliant boarding, NATO will take any further action required for the vessel to be inspected at the next legitimate opportunity (in the territorial waters of a NATO member state).<sup>160</sup> As a general case, then, maritime

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<sup>157</sup> NATO Briefing, “Combating Terrorism at sea,” *NATO E-Bookshop* (July 2006), 2.

<sup>158</sup> Hammick, “Navies endeavour to police the Mediterranean Sea,” 4.

<sup>159</sup> NATO Briefing, “Combating Terrorism at sea,” *NATO E-Bookshop* (July 2006), 3.

<sup>160</sup> Hammick, “Navies endeavour to police the Mediterranean Sea,” 4; Cesaretti, “Combating terrorism in the Mediterranean,” 2.

interdictions undertaken by OAE are in full compliance with the law of the sea, based either on the consent of the flag-state in international waters or the absolute jurisdiction of NATO member-states in their internal waters.

Since October 2004, an additional operational pattern has been adopted. Collected surveillance and intelligence data have been correlated in order not only to clarify suspect vessels at the request of patrolling units, but also to generate a list of specific vessels of interest. As a result, these vessels of interest may be continuously monitored by available means and specific NATO assets may be assigned to track or board them if necessary.<sup>161</sup>

Operation Active Endeavour's success and increased efficacy in the East Mediterranean led to expansion of its geographic area of operations to include the entire Mediterranean Sea, as of March 2004. A measure of its success is found in the following figures; as of 13 July 2006, 81,000 ships had been hailed and 102 suspect vessels had been boarded.<sup>162</sup> In addition, another measure of increased efficacy is that, in a sea where at any time "there are around 7,000 ships," the Maritime Operations Centre (MOC) at CC-Mar Naples is in position to regularly track 6,000 vessels simultaneously, based on data from all currently available resources (deployed naval units, land-based Maritime Patrol Aircrafts (MPAs) and coastal radar positions).<sup>163</sup>

Nevertheless, the existing doctrines and monitoring system are not infallible, as demonstrated by an event not directly related to Active Endeavour. On March 23, 2007, a 15-member boarding party from the *HMS Cornwall* that had been inspecting a merchant dhow in the Arabian Gulf was captured by the Iranian Revolutionary Guard. As a result of this unprecedented incident, the NATO MIO boarding doctrine is under revision in order to encompass new precepts being developed by the Royal Navy.<sup>164</sup>

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<sup>161</sup> NATO Briefing, "Combating Terrorism at sea," *NATO E-Bookshop* (July 2006), 3.

<sup>162</sup> *Ibid.*, 4.

<sup>163</sup> Hammick, "Navies endeavour to police the Mediterranean Sea," 2,6,7.

<sup>164</sup> Hammick, "Navies endeavour to police the Mediterranean Sea," 4.

This ongoing doctrinal review falls under NATO's continual efforts to build MIO expertise, especially since the establishment in 2004 of the NATO Maritime Interdiction Operational Training Centre (NMIOTC). The NMIOTC is located on the Souda Bay Naval BAse in Crete, Greece (one of the two principal bases used for Active Endeavour ships, along with Aksaz, Turkey). It has as its main mission to provide "realistic and flexible training in major fields that may include the boarding process, special operations, WMD, CBRN, damage control, navigation in restricted areas, MIO planning, maritime law enforcement, international organizations, international law/human rights and international terrorism" for NATO allies and partners.<sup>165</sup> The combination of knowledge provided in these fields demonstrates NATO's commitment to providing expertise in probable cause-related issues, not only to the higher ranks of the chain of command, but to the actual implementors of a maritime interdiction decision-making process.

*c. Exercises*

NATO's commitment to expertise is further demonstrated by relevant exercises such as "Phoenix Express 2008." Phoenix Express is an annually held exercise that is specifically focused on the "conduct of maritime interdiction operations (MIO) and visit, board, search and seizure (VBSS) operations."<sup>166</sup> It has two phases: the first includes theoretical and practical training ashore at the NMIOTC and the second is conducted at sea with real-life simulation scenarios. More specifically, participants from Algeria, Greece, Malta, Morocco, Portugal, Spain, Tunisia, Turkey, and the U.S. have conducted in total 23 boarding scenarios, using helicopters or RHIBs.<sup>167</sup>

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<sup>165</sup> Michael Naoum, Commander Hellenic Navy General Staff, "NATO Maritime Interdiction Operational Training Center," NATO & PfP Advanced Distributed Learning, <https://jadl.act.nato.int/npetn/files/NMIOTC.PPT>.

<sup>166</sup> United States Navy, "Phoenix Express 2008 (PE 08) Successfully Wraps in Augusta Bay," Nassau Strike Group Public Affairs Office (April 25, 2008), [http://www.navy.mil/search/display.asp?story\\_id=36628](http://www.navy.mil/search/display.asp?story_id=36628); WorldTribune.com, "Libya to take part in NATO exercise," WorldTribune.com (April 4, 2008). [http://www.worldtribune.com/worldtribune/WTARC/2008/me\\_libya0021\\_04\\_03.asp](http://www.worldtribune.com/worldtribune/WTARC/2008/me_libya0021_04_03.asp).

<sup>167</sup> Ibid.

#### *d. Maritime Interdictions*

Similarly to the PSI, Operation Active Endeavour (OAE) attributes a high specific weight to intelligence and its sharing among NATO members and Mediterranean Dialogue partners. According to its Commanding Officer, Vice Admiral (Italian Navy) Roberto Cesaretti, the ultimate goal for the operation is to advance information collection, analysis, and sharing to a level where it is capable of shifting OAE status from “intelligence-supported to intelligence-driven.”<sup>168</sup> Nevertheless, even the existing OAE status resulted in the successful interdiction of the *Baltic Sky* in June 2003. This vessel had been acting in a suspicious manner for almost a two-month period before finally being intercepted. It had left Albania on April 22, 2003, and was sailing under a Comoros flag when it arrived in Gabes, Tunisia, on May 12. In Tunisia, it loaded up its cargo, supposedly bound for Sudan. However, nine days later it was spotted by Turkish authorities in the Dardanelles. From May 22 until June 1, it was monitored sailing in the Mediterranean without making any port. On June 2, it arrived in Istanbul where it stayed for only one day, and then it sailed again through the Aegean archipelago, entering Greek territorial waters in the Ionian Sea on June 18.<sup>169</sup> The fact that the ship had been suspiciously wandering in the waters adjacent to Greece and Turkey, although allegedly delivering its cargo to Sudan, attracted the attention of CC-MAR Naples which then took action by disseminating this information to either NATO or national authorities.<sup>170</sup> As a result, the *Baltic Sky* was put under close surveillance by the Greek Coast Guard for the next five days. On June 22, it was subsequently boarded and searched by Greek authorities, which found in its cargo 680 tonnes of explosives and 8,000 detonators. It was also discovered that the alleged recipient in Sudan was a non-existent company.

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<sup>168</sup> NATO Briefing, “Combating Terrorism at sea,” *NATO E-Bookshop* (July 2006), 3.

<sup>169</sup> The Hellenic Radio (ERA), “News in Greek, June 24, 2003,” The Hellenic Radio, <http://www.hri.org/news/greek/eragr/2003/03-06-24.eragr.html#01>; CNN World. “Greece traces route of seized ship.” CNN World (June 24, 2003) <http://edition.cnn.com/2003/WORLD/europe/06/23/greece.ship/>.

<sup>170</sup> NATO Briefing, “Combating Terrorism at sea,” *NATO E-Bookshop* (July 2006), 4.

An overall assessment of the *Baltic Sky* interdiction in probable cause terms qualifies it as legal under the law of the sea. First, it was concluded for “security reasons”<sup>171</sup> in the territorial waters of the boarding state; second, the ship, though flying a Comoros flag, was actually registered in the Marshall Islands; and third, the vessel was found not to be in possession of the proper documents.<sup>172</sup>

**e. *NATO and the PSI***

The PSI, being “an activity, not an organization,”<sup>173</sup> lacks permanent establishments such as an MOC or NMIOTC. This has certain drawbacks, such as depriving it of standing assets; however, it allegedly offers flexibility and does not preclude further cooperation with standing organizations, even NATO itself. On the contrary, during the Istanbul summit of June 2004 the allies declared their “strong support” for the PSI and have also evaluated Operation Active Endeavour as being “highly relevant in this context.”<sup>174</sup>

**B. POTENTIAL ALTERNATIVES**

Existing approaches to establishing probable cause for maritime interdictions of illicit radioactive materials are strictly limited – within the framework of the law of the sea – to the provision of consent by the flag state on the high seas or to sovereign jurisdiction of the coastal state in its own internal and territorial waters. However, due to the great menace that radioactive materials pose in the wrong hands, there have been proposals to strengthen these interdictions by either implementing multilaterally binding decisions and agreements or by unilateral enforcement actions justified on the reinterpretation of existing law.

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<sup>171</sup> Song, “The U.S.-Led Proliferation Security Initiative and UNCLOS: Legality, Implementation, and an Assessment,” 122.

<sup>172</sup> Ibid.

<sup>173</sup> Song, “The U.S.-Led Proliferation Security Initiative and UNCLOS: Legality, Implementation, and an Assessment,” 105.

<sup>174</sup> NATO Briefing, “Combating Terrorism at sea,” *NATO E-Bookshop* (July 2006), 6.

## 1. 2005 Protocol to the Convention for the Suppression of Unlawful Acts against the Safety of Maritime Navigation (SUA Convention)

The SUA Convention is a treaty signed under the aegis of the International Maritime Organization (IMO) in the aftermath of the cruise ship the *Achille Lauro*'s hijacking.<sup>175</sup> Since the illegal acts committed during the incident were for political and not private ends, the standards set by the definition of piracy<sup>176</sup> could not be satisfied. At the request of several countries, the SUA Convention was put forward by the IMO Assembly in order to "ensure that appropriate action is taken against persons committing unlawful acts against ships. These include the seizure of ships by force; acts of violence against persons on board ships; and the placing of devices on board a ship which are likely to destroy or damage it."<sup>177</sup> The convention was opened for signature on March 10, 1988 and entered into force on March 1, 1992.<sup>178</sup>

In a similar way to the *Achille Lauro* incident, the terrorist attacks on September 11, 2001, initiated a procedure of redefining the list of unlawful acts, as well as going one step further: establishing procedures for exercising jurisdiction over them.<sup>179</sup> The procedure for the proposed amendment of the convention began on April 2002, during the eighty-fourth session of the IMO Legal Committee. The intent from the beginning was to criminalize, under certain conditions, the transport of WMD and related materials at sea and to incorporate boarding provisions when such a crime is committed. The Final Act was signed more than three years later on October 14, 2005, after a conference that, in the words of the IMO Secretary General Mr Efthimios E. Mitropoulos, was the "most

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<sup>175</sup> The *Achille Lauro* was hijacked on October 7, 1985 off Port Said, Egypt by four members of the Palestine Liberation Front (PLF), who demanded the release of 50 Palestinians then held in Israeli prisons. As a result, the ship was redirected to another destination and an American passenger was killed. See Christopher Young, "Balancing Maritime Security and Freedom of Navigation on the High Seas: A Study of the Multilateral Negotiation Process in Action," *University of Queensland Law Journal* 24, no. 2 (2005): 357.

<sup>176</sup> As described in Article 101 of the UNCLOS.

<sup>177</sup> IMO website, "Convention for the Suppression of Unlawful Acts Against the Safety of Maritime Navigation, 1988," IMO website, [http://www.imo.org/Conventions/mainframe.asp?topic\\_id=259&doc\\_id=686](http://www.imo.org/Conventions/mainframe.asp?topic_id=259&doc_id=686).

<sup>178</sup> Ibid.

<sup>179</sup> Klein, "Legal Limitations on Ensuring Australia's Maritime Security," 326.

politically charged” in IMO history.<sup>180</sup> This was because on one side, states like the U.S. advocated for fewer restrictions concerning the boarding of one state-party ship by officials of another state-party, whereas others were concerned about “the potential lack of compatibility between the proposed boarding procedures and the principles of freedom of navigation and the flag state jurisdiction.”<sup>181</sup>

The protocol, recalling UNSC Resolutions 1368 and 1373, which reflect international will to combat terrorism, and Resolution 1540 which aims to prevent nuclear proliferation, addresses the issue of probable cause in maritime interdictions of illicit radioactive materials in two proposed articles, *3bis* and *8bis*.<sup>182</sup>

Article *3bis* states that any person commits an offense within the meaning of the SUA Convention if that person unlawfully and intentionally transports on board a ship:

- (i) any explosive or radioactive material, knowing that it is intended to be used to cause, or in a threat to cause, with or without a condition, as is provided for under national law, death or serious injury or damage for the purpose of intimidating a population, or compelling a government or an international organization to do or to abstain from doing any act; or
- (ii) any BCN weapon, knowing it to be a BCN weapon as defined in article 1; or
- (iii) any source material, special fissionable material, or equipment or material especially designed or prepared for the processing, use or production of special fissionable material, knowing that it is intended to be used in a nuclear explosive activity or in any other nuclear activity not under safeguards pursuant to an IAEA comprehensive safeguards agreement; or
- (iv) any equipment, materials or software or related technology that significantly contributes to the design, manufacture or delivery of a BCN weapon, with the intention that it will be used for such purpose.<sup>183</sup>

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<sup>180</sup> Christopher Young, “Balancing Maritime Security and Freedom of Navigation on the High Seas: A Study of the Multilateral Negotiation Process in Action,” 384.

<sup>181</sup> Ibid., 358-359.

<sup>182</sup> The full text of the 2005 SUA Protocol is accessible at <http://www.state.gov/documents/organization/58426.pdf>.

<sup>183</sup> 2005 SUA Protocol, Article *3bis*.

An exemption is made if the materials are being transported to or from states which are party to the NPT and under the condition that such transport is not contrary to that state's obligations under that treaty. Moreover, Article 11bis provides that none of the offenses defined in article 3bis should be considered as "political ... or ... inspired by political motives" (the claim that led to the exclusion of the offenses committed on board the *Achille Lauro* from being identified as acts of piracy). However, what leaves ground for potential interpretation or dispute is the question of "intent."<sup>184</sup> Since intention is a precondition for characterizing the transport of radioactive materials as an offense, then apart from establishing a reason for suspicion that these materials are actually being transported, evidence must also be presented that the transporter (whether the shipping company, the ship's master, the crew, or whoever) was aware of both the malicious end-use and end-user. This condition, if the protocol enters into force, might considerably impede probable cause establishment.<sup>185</sup>

In response to the offenses described in Article 3bis, the 2005 SUA Protocol also specifies the procedural framework by which boarding may take place to "prevent and suppress"<sup>186</sup> these offenses. Any request by a state-party to board a vessel of another state-party (from here, the flag state) must be in accordance with international law.<sup>187</sup> The requesting state may request consent to board only under the prerequisite of "reasonable grounds to suspect that the ship or a person on board the ship has been, is or is about to be involved in the commission of an offence," and provided that the ship is sailing outside the territorial waters of any state.<sup>188</sup>

In doing so it must also provide, if possible, "the name, the IMO ship identification number, the port of registry, the ports of origin and destination, and any other relevant information" concerning the suspect vessel.<sup>189</sup> This information coincides

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<sup>184</sup> Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 133.

<sup>185</sup> Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 133.

<sup>186</sup> 2005 SUA Protocol, Article 8bis(1).

<sup>187</sup> Ibid.

<sup>188</sup> Ibid., Article 8bis(5)

<sup>189</sup> Ibid., Article 8bis(2)

with data collected by NATO warships as part of “hailing” procedures and, to a more general extent, with information collected by all warships when exercising the right of approach. It is also noteworthy that the protocol does not explicitly refer to providing the actual reason for suspicion, much less evidence to prove the suspicion. However, even if the flag state chooses to authorize the boarding of one of its vessels, it retains the right to set forth conditions for doing so, “including obtaining additional information from the requesting Party.”<sup>190</sup> Thus, on one hand, the flag state does not abrogate its sovereignty rights without legal justification and proof, and on the other, the need on the behalf of the requesting state arises for evidence of sources that can be relatively “publishable” and not as sensitive as intelligence.

Going back to the actual process, the requesting party must first ask for verification of the ship’s declared nationality. If the vessel is properly registered, the requesting state may ask not only to stop, board, and search the ship, but also to question her crew for verification of the suspected offenses.<sup>191</sup> In such a case, the flag state, apart from the obvious option of rejecting the demand, may choose to board the vessel by its own authority, provide consent, or opt for a combined action with the requesting state. In parallel, it can impose any conditions it deems appropriate. In any case, the flag state should respond to the request “as expeditiously as possible,”<sup>192</sup> a requirement that imposes no specific time constraint on the flag state.<sup>193</sup>

In order to facilitate the consent-granting procedures, the protocol sets forth two more options for the flag state: to provide *a priori* consent to all requests, by notifying the secretary-general of IMO upon accession to the treaty, or, by notifying the secretary-general of IMO and rendering consent as automatically granted if no response is provided by its part “within four hours of acknowledgement of receipt of a request to confirm

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<sup>190</sup> 2005 SUA Protocol, Article 8bis(7).

<sup>191</sup> 2005 SUA Protocol, Article 8bis(5)(b).

<sup>192</sup> *Ibid.*, Article 8bis(1).

<sup>193</sup> The U.S. had, during the process pressed, for a four hour time limit, which was regarded as “impracticable” by other states. See Klein, “Legal Limitations on Ensuring Australia’s Maritime Security,” 327.

nationality.”<sup>194</sup> Still, these procedures for *a priori*, or express, authorization are optional and even if relevant notifications are made to the secretary-general of IMO, they can be revoked at any time.

Finally, after the boarding and search have taken place, the flag state is to be promptly informed of any findings. Even if evidence of unlawful acts is discovered, the flag state retains exclusive jurisdiction over the ship, cargo, and crew, and it remains at its discretion whether to delegate this jurisdiction to the requesting state for issues of seizures and arrests.<sup>195</sup>

Still, as Klein points out, an obvious omission of the 2005 SUA Protocol is the complete absence of any specific obligations imposed on the flag state to undertake positive action in respect to a ship under its registry, reasonably suspected of being engaged in an unlawful act.<sup>196</sup>

As of June 30, 2008, only four states, corresponding to 5.09% of world tonnage, have ratified the protocol,<sup>197</sup> which will enter into force 90 days after the date on which 12 states have ratified it.<sup>198</sup> In an overall assessment, the 2005 SUA Protocol, if entered into force, will be a positive step in terms of implementing probable cause for maritime interdictions of illicit nuclear materials by specifying when the transport of related materials is illicit. Nonetheless, it does not foretell any radical innovation in existing legal framework. During the negotiating sessions, as one report notes, “it was accepted that the principle of flag state jurisdiction must be respected to the utmost extent.”<sup>199</sup> This, along with other provisions, qualifies the protocol as being in total conformity with existing law

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<sup>194</sup> 2005 SUA Protocol, Article 8bis(5)(d) and (e).

<sup>195</sup> Ibid., Article 8bis(6) and (8).

<sup>196</sup> Klein, “Legal Limitations on Ensuring Australia’s Maritime Security,” 328.

<sup>197</sup> IMO website, “Summary of Status of Conventions,” as at August 31, 2008, [http://www.imo.org/Conventions/mainframe.asp?topic\\_id=247](http://www.imo.org/Conventions/mainframe.asp?topic_id=247).

<sup>198</sup> IMO website, “Convention for the Suppression of Unlawful Acts Against the Safety of Maritime Navigation, 1988,” IMO website, [http://www.imo.org/Conventions/mainframe.asp?topic\\_id=259&doc\\_id=686](http://www.imo.org/Conventions/mainframe.asp?topic_id=259&doc_id=686).

<sup>199</sup> IMO Legal Committee, Report of the Legal Committee on the Work of Its Eighty-Eighth Session, LEG 88/13, 88th sess, Agenda Item 13 (May 18, 2004) [66] as cited in Klein, “Legal Limitations on Ensuring Australia’s Maritime Security,” 329.

of the sea. Moreover, from a purely legal perspective, the protocol has only the status of a multilateral treaty, binding only on those states which have ratified it. While the claim is that a multilateral treaty may be conceived as “reflecting, or as crystallizing, received or at least emergent rules of customary international law,” the protocol won’t be considered as binding on non-party states of proliferation concern<sup>200</sup> and thus cannot be universally invoked for establishment of probable cause.

## **2. Enhancement through a New UNSC Resolution**

Another alternative that would definitely overcome any obstacles for legal justification of probable cause in international waters is a new UNSC resolution. First, under Chapter VII of the UN Charter, the UNSC may authorize the use of enforcement actions (such as maritime interdictions) against any perceived threat to international peace and security. Second, under Article 25 of the UN Charter, its decisions are legally binding on all states regardless. With the proposed resolution, the UNSC would decide that the illicit trafficking of radioactive materials, or in a more generalized sense WMD, constitutes an unlawful act of universal jurisdiction,<sup>201</sup> a status currently shared on the high seas only by piracy, the slave trade and unauthorized broadcasting.<sup>202</sup>

The prospects and potential benefits of such a resolution clearly have not escaped the attention of the involved actors. On the contrary, Resolution 1540 was initially intended by the U.S. and the UK as a tool that would explicitly extend the jurisdiction, on the high seas, of states to interdict vessels suspected of transporting WMD-related materials.<sup>203</sup> However, the concerns of other states about abrogating the exclusive flag state jurisdiction, as well as potential harassment of legitimate shipping and abuse of

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<sup>200</sup> Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 175.

<sup>201</sup> Ibid., 148.

<sup>202</sup> UNCLOS, Article 110.

<sup>203</sup> Klein, “Legal Limitations on Ensuring Australia’s Maritime Security,” 333.

right,<sup>204</sup> led to a compromise<sup>205</sup> at the behest of the freedom of navigation. Thus, any future resolution seeking to add legitimacy to policing the oceans against the proliferation of WMD will have to carefully balance *mare liberum* with maritime security in order, first, to be approved by the UNSC<sup>206</sup> and, then, to be received with the same widespread consensus as the provisions of existing international law on combating piracy and slave trade.

### **3. The War on Terrorism and the Belligerent Status Claim**

Regarding potential alternatives to promote maritime security, both the 2005 SUA Protocol and the proposed UNSC resolution share the common characteristic of seeking to amend the existing legal framework by achieving consensus at the political level. Since consensus has proved barely attainable in terms of interdicting WMD-related materials at sea, scholars and experts have put forth other options that are based not on amendment, but reinterpretation of existing positive or customary international law. One of those is the war on terrorism and the belligerent status claim.

According to the law of neutrality, belligerents enjoy during war the right to search and visit not only vessels of the enemy, but also neutral merchant vessels under certain conditions. The interdiction must take place outside neutral waters (i.e. outside the territorial waters of any third party to the conflict state) and the cargo must be ultimately destined to the enemy and “susceptible for use in armed conflict.”<sup>207</sup> Clearly, fissile, and, to a certain extent, other radioactive materials could fall within the latter category.

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<sup>204</sup> According to Article 300 of the UNCLOS, states “shall exercise the rights, jurisdiction and freedoms recognized in this Convention in a manner which would not constitute an abuse of right.”

<sup>205</sup> Persbo and Davis, “Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea,” 76.

<sup>206</sup> According to the UN Charter, Article 28, such a decision would require the “affirmative vote of nine members including the concurring votes of the permanent members.”

<sup>207</sup> Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 92.

As Doolin remarks, belligerent status has been viewed as relevant to the war on terrorism in operations such as “Iraqi Freedom” and “Enduring Freedom.”<sup>208</sup> Nevertheless, invoking belligerent status for broader in context operations, like those undertaken by PSI or NATO would signify the prerequisite of a UNSC resolution. Even if a country like the U.S. chose a similar course of action for unilateral operations, it would face practical restrictions. Declarations of war are traditionally issued by states against states. Hence, in targeting Al-Qaida’s potential host states, the U.S. would be obliged to declare war against at least eleven countries.<sup>209</sup> Given these discrepancies, the belligerent status claim does not seem applicable for promoting maritime interdictions of radioactive materials.

#### **4. The Doctrine of Self-Help**

The doctrine of self-help was a widely accepted component of customary law until the end of World War II, entitling a state to protect its rights against a violation by another state, using all means that it deemed as appropriate.<sup>210</sup> However, the introduction of the UN Charter in 1945 significantly curtailed the spectrum of these appropriate means, declaring that all states shall “refrain in their international relations from the threat or use of force … in any manner inconsistent with the purposes of the United Nations.”<sup>211</sup> As a result, and in order to codify self-help in the newly formed world order, the International Law Commission (ILC), during its first session in 1949, identified the “responsibility of states for internationally wrongful acts” as an issue of priority.<sup>212</sup> More than half a century later, the current state of affairs is the one established by the fifty-third session, in 2001, which adopted a final set of 59 draft articles on Responsibility of States

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<sup>208</sup> Doolin, “The Proliferation Security Initiative: Cornerstone of a New International Norm,” 45.

<sup>209</sup> 9/11 Commission Report, 365-367, as cited in Doolin, “The Proliferation Security Initiative: Cornerstone of a New International Norm,” 45.

<sup>210</sup> Christian Tomuschat, “Are Counter-measures Subject to Prior Recourse to Dispute Settlement Procedures?” *European Journal of International Law* 5, no. 1 (1994): 77.

<sup>211</sup> UN Charter, Article 2(4).

<sup>212</sup> United Nations Treaty Collection, “State Responsibility,” International Law Commission, [http://untreaty.un.org/ilc/summaries/9\\_6.htm](http://untreaty.un.org/ilc/summaries/9_6.htm).

for Internationally Wrongful Acts,<sup>213</sup> and which invited world governments “to submit their written comments on any future action regarding the articles.”<sup>214</sup> It is clear that the self-help doctrine is a highly controversial political and legal issue.

Nevertheless, Allen asserts that the existing framework could provide grounds for maritime interdictions. After acknowledging Myres McDougal’s view that such countermeasures are appropriate due to the lack of a global sovereign authority,<sup>215</sup> Allen argues that, although restricted in use of force terms by the UN Charter, the right of non-forcible self-help “has not been extinguished.”<sup>216</sup> Under the ILC Draft Articles on state responsibility, an injured state may take countermeasures against a state that is responsible for an internationally wrongful act, proportionate to the injury suffered and to the gravity of the internationally wrongful act.<sup>217</sup> Moreover, trying to clarify the distinction between forcible and non-forcible countermeasures, Allen classifies policing of the oceans as non-forcible.

Given these points, Allen associates self-help with UNCLOS. Apart from UNCLOS Article 110, which clearly defines the cases in which the *right of visit* applies on the high seas, Articles 25 and 221 connote self-help, stating that a “coastal state may resort to extrajudicial countermeasures” within and beyond its territorial waters by invoking either a *non-innocent passage* or pollution-related reasons.<sup>218</sup>

Beyond that, any attempt to justify with the self-help doctrine a maritime interdiction on the grounds of a flag state’s failure to comply with its obligations under UNSC Resolution 1540 would be cumbersome. The primary reason is that nowhere in the

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<sup>213</sup> Full text available at United Nations, “Responsibility of States for Internationally Wrongful Acts,” Yearbook of the International Law Commission, 2001, vol. II (Part Two), [http://untreaty.un.org/ilc/texts/instruments/english/draft%20articles/9\\_6\\_2001.pdf](http://untreaty.un.org/ilc/texts/instruments/english/draft%20articles/9_6_2001.pdf).

<sup>214</sup> Ibid.

<sup>215</sup> Myres S. McDougal, “Authority to Use Force on the High Seas,” *U.S. Naval War College International Law Studies* 61 (1979): 551, 555, as cited in Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 135.

<sup>216</sup> Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 136.

<sup>217</sup> Articles 49, 51 of the ILC Draft Articles on Responsibility of States for Internationally Wrongful Acts.

<sup>218</sup> Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 137-138.

original text of the resolution is it written or implied that a flag state's failure to "adopt and enforce appropriate effective laws"<sup>219</sup> for the prohibition of WMD transport or to provide consent for boarding by a third-party state constitutes an internationally wrongful act. On the contrary, due to the recorded objections of some UNSC members regarding alteration of the existing maritime interdictions regime, as well as due to the explicit decision to remain seized on the matter, the Security Council reserves for itself the authority for further interpretation or action under this resolution.<sup>220</sup>

Generally, the assertion that self-help countermeasures provide ground for legally justifying probable cause in maritime counter-proliferation operations, could easily be countered with the argument that this ground is not solid, since it should only be seen in conjunction with the greater specific weight carried by the relevant provisions of UNCLOS and UNSC resolutions. Thus, the existing legal status of self-help cannot significantly contribute to establishing probable cause for boarding a foreign flagged vessel.

## 5. The Doctrine of Necessity

A more realistic potential alternative is the doctrine of necessity. Attributed originally to Hugo Grotius,<sup>221</sup> the doctrine of necessity justifies an otherwise unlawful action when "the very existence of a state is in peril."<sup>222</sup> With that main precondition, necessity "supersedes all laws,"<sup>223</sup> when it is actual and not simply discerned, and when all other available means for the state in question to preserve its existence have been exhausted. The M/V *Torrey Canyon* case set a legal precedent by which necessity can be successfully implemented even if its main precondition is not met. On March 18, 1967, the tanker *Torrey Canyon* ran aground on a reef off the coast of Cornwall, United

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<sup>219</sup> UNSC Resolution 1540.

<sup>220</sup> Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 170.

<sup>221</sup> Hugo Grotius, *The Law of War and Peace: De Jure Belli Ac Pacis Libri Tres*, trans. Francis W. Kelsey (Indianapolis: Bobbs-Merrill, 1962).

<sup>222</sup> Persbo and Davis, "Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea," 78.

<sup>223</sup> Persbo and Davis, "Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea," 78.

Kingdom. The oil slick caused by her cargo of 100,000 tons of crude oil inflicted a great environmental catastrophe on the marine life of southwestern England and northwestern France. After all other attempts to minimize these disastrous effects had failed, the British Royal Air Force and Navy bombed the *Torrey Canyon* in an effort to sink it and burn off its remaining oil cargo. The ship was owned by a U.S. company, registered under a Liberian flag and sailed by an Italian master, so, in order to legally justify bombing, the UK invoked the doctrine of necessity.<sup>224</sup> A retrospective examination of the incident by the International Law Commission assessed that, although the existence of the appealing state was not in peril, if the shipping company had tried to make use of its ownership rights to prevent the destruction of the vessel, the UK's action "would have had to be recognized as internationally lawful because of a state of necessity."<sup>225</sup>

In this respect, the International Law Commission has also included a revision of necessity in Article 25 of the aforementioned draft articles on Responsibility of States for Internationally Wrongful Acts. This revision includes the following provisions:

- I. Necessity may not be invoked by a State as a ground for precluding the wrongfulness of an act not in conformity with an international obligation of that State unless the act:
  - (i) is the only way for the State to safeguard an essential interest against a grave and imminent peril; and
  - (ii) does not seriously impair an essential interest of the State or States towards which the obligation exists, or of the international community as a whole.

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<sup>224</sup> BBC Home, On This Day: March 29, 1967, "Bombs Rain Down on Torrey Canyon," [http://news.bbc.co.uk/onthisday/hi/dates/stories/march/29/newsid\\_2819000/2819369.stm](http://news.bbc.co.uk/onthisday/hi/dates/stories/march/29/newsid_2819000/2819369.stm); Grey Hall, "Torrey Canyon Altered the World to the Dangers That Lay Ahead," *Professional Mariner, Journal of the Maritime Industry* 103 (Apr/May 2007), <http://professionalmariner.com/ME2/dirmod.asp?sid=&nm=&type=Publishing&mod=Publications::Article&mid=8F3A7027421841978F18BE895F87F791&tier=4&id=AB1BEA4C5E974EA79C889DE5ACFF20C9>; Persbo and Davis, "Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea," 79.

<sup>225</sup> Report of the International Law Commission on the work of its thirty-second session, UN Doc A/35/10 (1980), § 15 as cited in Persbo and Davis, "Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea," 79.

II. In any case, necessity may not be invoked by a State as a ground for precluding wrongfulness if:

(i) The international obligation in question excludes the possibility of invoking necessity; or

(ii) The State has contributed to the situation of necessity.<sup>226</sup>

This definition of necessity has been similarly applied by the International Tribunal on the Law of the Sea during its verdict for the M/V *Saiga* case.<sup>227</sup> On October 28, 1997, the tanker *Saiga* and its crew were detained on the high seas of the mid-Atlantic Ocean by Guinean authorities and under the probable cause that the vessel was “involved in re-fuelling (bunkering) fishing vessels at sea within the Exclusive Economic Zone of Guinea.”<sup>228</sup> Due to the fact that the vessel was registered under Saint Vincent and the Grenadines flag and the interdiction was undertaken on the high seas, Guinea invoked the doctrine of necessity for legal justification of its actions. However, the international Tribunal on the Law of the Sea decided that “Guinea had not demonstrated that its essential interests were in grave and imminent peril, nor that extending its customs laws to the EEZ was the only means of safeguarding those interests,”<sup>229</sup> thus rendering necessity inapplicable in this case.

The question that arises is if in a hypothetical scenario, where there is solid ground to believe that illicit radioactive materials are underway on the high seas, a state other than the flag state could claim interdiction as the only course of action to protect itself against a “grave and imminent peril.”<sup>230</sup> Nuclear materials definitively constitute a grave and imminent peril, even more so if their final recipient is a non-state terrorist organization. The peril should also be considered as extending not only to the concerned

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<sup>226</sup> Article 25 of the United Nations, “Responsibility of States for Internationally Wrongful Acts.”

<sup>227</sup> Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 173.

<sup>228</sup> International Tribunal for the Law of the Sea, “First Round of Written Pleadings Filed in M/V *Saiga* (No. 2) Case,” ITLOS Press 17 (October 19, 1998), 2, [http://itlos.mcs-world.de/news/press\\_release/1998/press\\_release\\_17\\_en.pdf](http://itlos.mcs-world.de/news/press_release/1998/press_release_17_en.pdf)).

<sup>229</sup> Louise de la Fayette, “International Tribunal for the Law of the Sea: The M/V *Saiga* (No.2) Case (St. Vincent and the Grenadines versus Guinea), Judgment,” *The International and Comparative Law Quarterly*, 49, No. 2, (April, 2000): 472, <http://www.jstor.org/stable/761689>).

<sup>230</sup> Persbo and Davis, “Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea,” 80.

state, but also to the global community as a whole.<sup>231</sup> Moreover, if previous attempts to obtain consent for boarding from the flag state have failed or if any other reasons qualifying for the right of visit are not applicable, then, given the strict context of relevant international law, an interdiction justified on the doctrine of necessity is clearly the last and only means available of safeguarding a state's security.<sup>232</sup>

Nevertheless, the primary hypothesis on which this scenario was based is not foolproof: intelligence must be of a high enough quality to merit an unassailable decision to board. First, the discrediting of intelligence in the current Iraq war<sup>233</sup> will most likely raise the standards of the international community and institutions in post-justifying an otherwise unlawful intervention, such as boarding a foreign vessel. In any case, the source of information or intelligence will have to be revealed, a condition with which the intelligence services of any state will be reluctant to comply.<sup>234</sup> Furthermore, the dual-use nature of radioactive materials will make it even more difficult to identify their real end-user, increasing the possibility of actually disrupting legitimate shipping.<sup>235</sup>

Last, but not least, the infringement of freedom of navigation by a state's unilateral action invoking necessity, will most likely initiate a chain reaction of similar interdictions by other states and potentially malevolently intended against the first state's interests. Such a prospect will erode the foundations of the international legal structure

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<sup>231</sup> UNSC Resolution 1540 (2004).

<sup>232</sup> Persbo and Davis, "Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea," 80.

<sup>233</sup> Persbo and Davis, "Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea," 10, 80. Another report refers to: "[S]pectacularly bad intelligence prepared by the IC in the run-up to the war in Iraq." See U.S. Senate Select Committee on Intelligence, "Report on Whether Public Statements Regarding Iraq by U.S. Government Officials were substantiated by Intelligence Information," U.S. Senate Select Committee on Intelligence Publications 110<sup>th</sup> Congress, 2<sup>nd</sup> Session (June 2008), 170, <http://intelligence.senate.gov/080605/phase2a.pdf>.

<sup>234</sup> Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 173.

<sup>235</sup> Persbo and Davis, "Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea," 80.

beyond any remedy.<sup>236</sup> It is in the interest of all states to take such a course of action only as a last resort and in exceptional cases. If, instead of the exception, the necessity justification became the rule, it would then constitute an abuse of right under international law.<sup>237</sup>

## **6. The Doctrine of Pre-Emptive or Anticipatory Self-Defense**

Similar to self-help and necessity, self-defense is another traditional notion of international law, which grants a state the right to take up action against an aggressor. This action may also include the use of force, but it must be limited to measures necessary and proportionate to the aggression. The contemporary framework for these limits of self-defense is set by the UN Charter, which is again more restrictive in context compared to pre-World War II notions and practices.<sup>238</sup> Article 51 justifies self-defense only in the case of an actual armed attack, and only “until the Security Council has taken measures necessary to maintain international peace and security.” It is evident and beyond any interpretation that the bar for invoking self-defense in maritime interdiction operations is as a result set very high, whereas the notions of pre-emption or anticipation are not officially recognized attributes of self-defense.

There have been exceptions to this rule, with the *Caroline* incident setting the historical landmark. On December 29, 1837, British forces attacked the steamboat SS *Caroline* in the Great Lakes region. The ship was suspected of transporting arms and personnel in support of a Canadian rebellion to overthrow British rule, and the UK invoked a claim of anticipatory self-defense to justify the action. This incident has since then been used to set the defining principles of anticipatory self-defense, which the British failed to fulfill and which are considered to be: i) response to actual or threatened violence; ii) necessity; and iii) proportionality.<sup>239</sup>

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<sup>236</sup> Allen, *Maritime Counterproliferation Operations and the Rule of Law*, 174.

<sup>237</sup> Persbo and Davis, “Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea,” 81.

<sup>238</sup> Such as the preventive attacks of the Axis Powers, Germany and Japan. See Doolin, “The Proliferation Security Initiative: Cornerstone of a New International Norm,” 46.

<sup>239</sup> Doolin, “The Proliferation Security Initiative: Cornerstone of a New International Norm,” 46.

Obviously, the semantic differential is established by justifying response not only to actual, but also to threatened violence. Despite the fact that this clause seems to be eradicated by the UN Charter, there has still been some remaining inertia regarding its use. Though the U.S. has never formally invoked Article 51, Doolin cites the Cuban Missile Crisis of 1962 as highly relevant to the application of pre-emptive self-defense in maritime interdictions of nuclear weapons. The maritime interdiction operations during the crisis were formally undertaken with reference to the 1947 Inter-American Treaty of Reciprocal Assistance, commonly known as the Rio Pact.<sup>240</sup> This pact incorporates collective security/defense provisions for the American Continent/Western Hemisphere, which are also in conformity with Article 51 of the UN Charter.<sup>241</sup> Action taken by the U.S. under these articles was justified since, despite the fact that the issue was brought up to the UNSC, no measures necessary to maintain international peace and security were decided by the latter. Moreover, Doolin argues that the principles of necessity and proportionality were respected. The operation had the character of a “defensive quarantine” along “prescribed” sea lines of communication to Cuba and at a “reasonable distance” from it. The use of force was minimal, in contrast with other forms of action, such as sinking suspect vessels, as well as the disruption of legitimate shipping and freedom of navigation.<sup>242</sup> Last, he points out that these interdictions are cited as “a valid precedent.”<sup>243</sup> Even Doolin himself, however, does not characterize them as legal, but as “consistent with U.S. responsibilities under the UN Charter.”<sup>244</sup>

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<sup>240</sup> Leonard C. Meeker, “Defensive Quarantine and the Law,” *The American Journal of International Law*, 57, no. 3 (July, 1963): 522.

<sup>241</sup> Charles G. Fenwick, “The Atlantic Pact,” *The American Journal of International Law* 43, no. 2 (April 1949): 312-316; For full text of the treaty see <http://www.oas.org/juridico/english/Treaties/b-29.html>.

<sup>242</sup> Doolin, “The Proliferation Security Initiative: Cornerstone of a New International Norm,” 47.

<sup>243</sup> Ibid.

<sup>244</sup> Ibid.

Two other examples of anticipatory self-defense are attributed to Israel. The first is Operation “Noah’s Ark,” carried out on January 3, 2002, after months of intelligence activity.<sup>245</sup> On this day, the 4000-ton merchant vessel *Karine-A* was interdicted by Israeli authorities in the international waters of the Red Sea, between Saudi Arabia and Egypt, and almost 300 nautical miles away from the nearest port of the Israeli coast, the port of Eilat.<sup>246</sup> After the onboard search, over 50 tons of arms and ammunition were discovered, allegedly intended for the Palestinian Authority (PA). According to *Lloyd’s List*, a journal that tracks global shipping records, the vessel has been recently renamed and reregistered from the Lebanese flag to that of the Kingdom of Tonga, but ownership was disputed.<sup>247</sup> Regarding the incident, Israeli Prime Minister Ariel Sharon, among others, described the vessel as a “Ship of Terror” and said that its cargo “would have changed the strategic balance.”<sup>248</sup> Deputy Director General of the Israeli Foreign Ministry for Information, Gideon Meir, declared that “Israel is actually exercising its most basic security doctrine, which is the doctrine of self-defense.”<sup>249</sup> Despite the fact that this action lacked legitimacy under the law of the sea, it was not condemned by the UNSC,<sup>250</sup> probably due to the combination of Israel’s claims and the vessel’s registry under a flag of convenience, which did not bring the issue to the attention of an international legal institution.

The other Israeli action, although not in a maritime context, is more relevant in terms of the nuclear threat and a formal invocation of self-defense. On June 7, 1981, as part of Operation Opera, Israeli aircraft destroyed the Osirak nuclear plant in Iraq. Israel formally invoked self-defense on the grounds that the plant would be capable of

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<sup>245</sup> “Operation Milk and Honey” see Kirill, Oleg Granovsky, “Weapons Found on *Karine-A* and *Santorini*,” War Online, [http://www.waronline.org/en/analysis/pal\\_weapons.htm#karin](http://www.waronline.org/en/analysis/pal_weapons.htm#karin).

<sup>246</sup> Ibid.

<sup>247</sup> BBC news sec. Middle East, “Weapons Ship Mystery Deepens,” BBC news, [http://news.bbc.co.uk/2/hi/middle\\_east/1753233.stm](http://news.bbc.co.uk/2/hi/middle_east/1753233.stm).

<sup>248</sup> BBC news sec. Middle East, “Weapons Ship Mystery Deepens,” BBC news, [http://news.bbc.co.uk/2/hi/middle\\_east/1753233.stm](http://news.bbc.co.uk/2/hi/middle_east/1753233.stm).

<sup>249</sup> Israel Ministry of Foreign Affairs, “National Media Center opened in Jerusalem- First briefing to the press, March 29, 2002,” Israel Ministry of Foreign Affairs, <http://www.israel-mfa.gov.il/MFA/Government/Speeches%20by%20Israeli%20leaders/2002/National%20Media%20Center%20opened%20in%20Jerusalem-%20First%20b>.

<sup>250</sup> Doolin, “The Proliferation Security Initiative: Cornerstone of a New International Norm,” 47.

eventually producing nuclear weapons intended for use against Israel, thus posing a grave and imminent peril against its existence as a state. Iraq, on the other hand, denied both charges of capability and intent, and the issue was addressed to the United Nations in order to be resolved.<sup>251</sup> The verdict was delivered through the unanimously adopted UNSC Resolution 487, which strongly condemned “the military attack by Israel in clear violation of the Charter of the United Nations and the norms of international conduct,” while in parallel calling upon Israel to “refrain in the future from any such acts or threats thereof.”<sup>252</sup>

Although all of the aforementioned paradigms of anticipatory or pre-emptive self-defense (the SS *Caroline* incident, the Cuban Missile Crisis, Operation Noah’s Ark, and Operation Opera) have been characterized by success and relative impunity with regard to the invoking state, they have nevertheless been viewed merely as the exceptions to the general rule that the notions of pre-emption or anticipation do not comprise officially recognized attributes of self-defense. This rule was verified by a unanimous UNSC Resolution in the case of Operation Opera, when those injured by Israel’s pre-emptive attack made an appeal to the former’s jurisdiction. According to the UNSC, self-defense may only be invoked in the case of an ongoing or imminent attack or, for the purpose of interdicting radioactive materials at sea on board a ship sailing in the vicinity of the interdicting state’s waters, heading to one of its homeports, and positively known to be transporting a nuclear weapon. As recent experience in Iraq has demonstrated, intelligence on these issues has not yet reached the level of credibility required for one state to breach another’s sovereignty under the pretext of security or counter-proliferation operations. For these reasons, self-defense should only be used as a last resort option.

## **7. Creating Rules of Customary International Law**

The last of the probable cause justifications comes from the PSI and the potential it presents for creating rules of customary international law for boardings, instead of

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<sup>251</sup> Persbo and Davis, “Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea,” 82.

<sup>252</sup> United Nations, “United Nations Security Council Resolution 487,” United Nations, 1981, <http://daccessdds.un.org/doc/RESOLUTION/GEN/NR0/418/74/IMG/NR041874.pdf?OpenElement>.

merely applying such rules. Due to the fairly brief history of the PSI and its controversial reception among experts, scholars and states, this proposition involves the greatest degree of subjectivity, based largely on predictions alone.

On one side, Doolin, expressing a general expectation, claims that through the cluster of PSI agreements, exercises and interdictions, boarding a vessel suspected of carrying WMD materials will gradually evolve into a widely accepted practice.<sup>253</sup> Given the increasing number of participants<sup>254</sup> and maritime exercises, he sees two potential paths of evolution that could eventually lead to the amendment of Article 110 of UNCLOS: either the overwhelming majority of states that adhere to non-proliferation will proceed directly to the amendment of the right of visit; or the gradual proliferation of bilateral ship boarding agreements will make maritime interdictions of WMD a common practice, eventually incorporating them into the customary law of the sea. Whatever the actual case may be, this kind of approach belongs to the sphere of merely desirable, and though yet practicable for our contemporary analysis.

On the other side, Song, taking a more realistic approach, and basing his case on the record of previous PSI activities, argues that this prospect is not likely to be realized due to the absence of “a general practice of states in undertaking interdictions.”<sup>255</sup> PSI is an activity and not an organization, reflecting the political commitment of the participant states in interdicting radioactive materials at sea and only on an *ad hoc* basis. Thus, at least for the time being, PSI activities do not have any tangible effect on probable cause related customary law.

## C. CONCLUSION

Probable cause for maritime interdictions of illicit radioactive materials has two principal aspects: providing a valid reason and evidence for suspicion, as well as

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<sup>253</sup> Doolin, “The Proliferation Security Initiative: Cornerstone of a New International Norm,” 50-51.

<sup>254</sup> Accounting for 93 states as of October 6, 2008. See U.S. Department of State, Bureau of International Security and Nonproliferation. “Proliferation Security Initiative Participants.” <http://www.state.gov/t/isn/c19310.htm>.

<sup>255</sup> Song, “The U.S.-Led Proliferation Security Initiative and UNCLOS: Legality, Implementation, and an Assessment,” 134.

justifying the legality of the action under international law. Though these aspects share a substantial degree of overlap, it is evident that these currently existing restrictions have different origins.

By definition, “International Law is rooted in acceptance by the nation states which constitute the system. Customary law and conventional law are primary sources of international law.”<sup>256</sup> In the first place, existing legal restrictions are mainly due to the lack of political consensus between states in balancing maritime security with freedom of navigation (conventional law) and to the absence of common and consistent practices in terms of interdicting radioactive materials (customary law).

Intelligence and surveillance have also demonstrated limitations in their applicability and are largely considered to be inadequate to support controversial or last resort legal arguments, such as necessity or anticipatory self-defense.

Nevertheless, the restrictions posed by intelligence and surveillance in establishing probable cause could be overcome with the use of portal radiation detection monitors. Ongoing developments in this kind of technology present the potential for stand-off radiation detection and identification of the materials in question through non-intrusive means. Furthermore, the data provided by these portals are far less susceptible to dispute over credibility than intelligence, while also being publishable in a way that does not require the disclosure of any confidential files or sources. Radiation detection portal monitors may thus not only contribute to providing valid evidence for suspicion, but also to expunging some states’ fear that consenting to a more intrusive UNSC resolution (or law of the sea amendment) limiting the flag state’s currently exclusive jurisdiction would give grounds for abuse of right by certain states.

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<sup>256</sup> Cornell University Law School Legal Information Institute, “International Law: An Overview,” Cornell University Law School, [http://topics.law.cornell.edu/wex/international\\_law](http://topics.law.cornell.edu/wex/international_law).

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## **IV. ENHANCING PROBABLE CAUSE THROUGH DEVELOPMENT OF RADIATION DETECTION AND IDENTIFICATION TECHNOLOGY**

### **A. INTRODUCTION AND BACKGROUND**

Considerable work is ongoing to develop and field radiation detection and identification systems for measuring the presence of radioactive materials and for determining their identity. One such system that is being actively considered by the U.S. government for use in maritime applications is the Adaptable Radiation Area Monitor, or ARAM, which was developed by the Lawrence Livermore National Laboratory and then licensed to IST-Textron Systems.<sup>257</sup> In this thesis, the ARAM system is representative of the current state-of-the-art, and its performance has been evaluated to understand the potential and limitations of such equipment.

However, in order for this evaluation to take place the properties of radiation detection and identification technology must first be examined.

#### **1. Forms of Radiation**

The process of radioactive decay is always associated with the emission of particles or photons by the decaying atoms. These unstable atoms, during the process of transforming into daughter products (i.e., different elements of the periodic table or less excited forms of the same isotope), emit a certain combination of alpha particles, beta particles, neutrons, gamma rays and X-rays. Figure 3 illustrates the two most common processes of alpha decay and beta decay.

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<sup>257</sup> Berkeley Nucleonics Corporation, “Radiation Portal,” Berkeley Nucleonics Corporation, <http://www.berkeleynucleonics.com/radiationportal.html>.

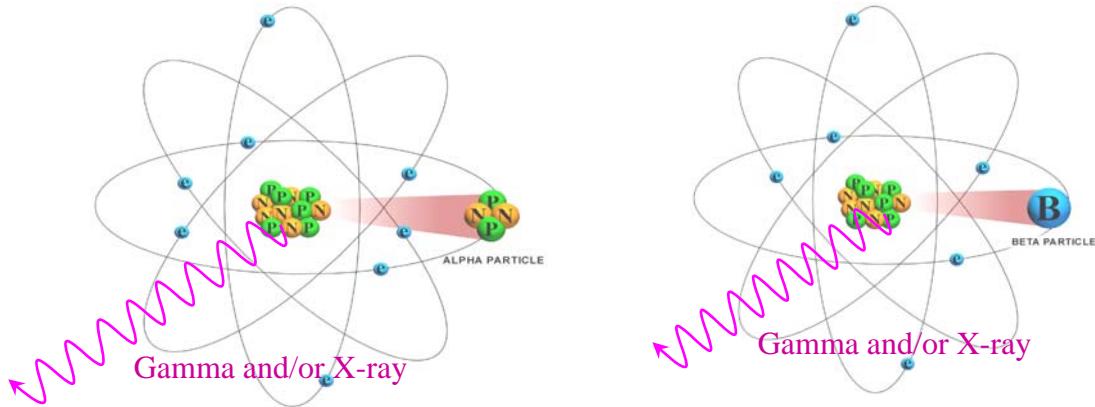


Figure 3. Illustration of Radioactive Decay.<sup>258</sup>

Alpha particles consist of two protons and two neutrons and generally have high energy, just as helium nuclei do; however, they can only travel a few inches through air and have minimal penetrability through even the least dense solid materials, such as a piece of paper or human skin. Beta particles, consisting of a positron or more usually an electron, are lighter than their alpha counterparts, but because of their smaller electric charge, have longer range and moderate penetrability; they can travel through several feet of air (10-20 feet) and it takes a denser material, such as aluminum, to absorb them along their path. Gamma and X-rays are not comprised of matter but of highly energetic electromagnetic radiation (compared to visible light, radio waves, or other forms of electromagnetic radiation). Their most important attribute, however, is a combination of the ability to travel long distances and to exhibit a high-penetrating capability; they can traverse hundreds of feet in the air and only very dense materials, such as lead or concrete of considerable thickness, are impenetrable to them.<sup>259</sup> Lastly, neutron radiation by far excels all other types of radiation in terms of range and penetrability, since even high

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<sup>258</sup> Brooke Buddemeier, Lawrence Livermore National Laboratory Nuclear Counterterrorism Program, “Understanding Radiation and Its Effects,” Lawrence Livermore National Laboratory, [http://www.nuc.berkeley.edu/news/Sci\\_teachers\\_workshop/understanding\\_radiation\(notices\).pdf](http://www.nuc.berkeley.edu/news/Sci_teachers_workshop/understanding_radiation(notices).pdf).

<sup>259</sup> Health Physics Society Public Information, “Radiation Basics,” Health Physics Society, <http://www.hps.org/publicinformation/ate/faqs/radiation.html>.

atomic number materials do not pose a serious impediment to it. As a result, neutrons can best be shielded by materials containing light atoms (e.g., hydrogen), such as concrete blocks, water, or other combinations of thick-layered shielding.

From these descriptions of the characteristic transport and penetration properties of various radiation types, which are visually presented in Figure 4, it is evident that for the purpose of remote detection and identification of radioactive materials, gamma/X-rays and neutrons are of primary interest in terms of operational exploitation in the field. It should also be noted that the phenomenon of shielding (or, more broadly, the attenuation of radiation as it passes through matter), is just one of the four key parameters that determine the response of a sensor to a given radioactive source, the other three being distance, solid angle of the detector, and time.

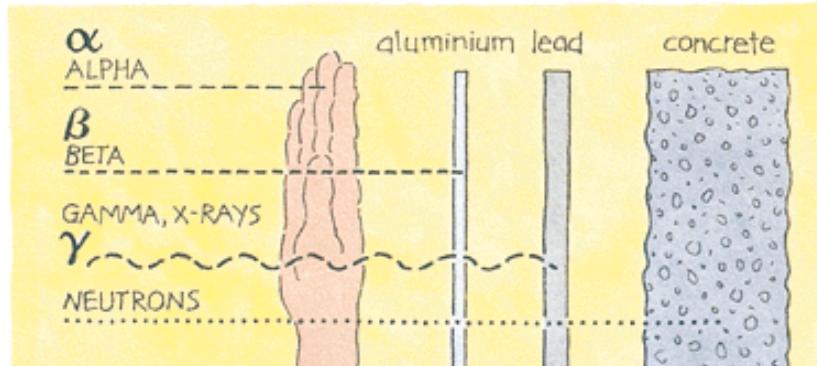


Figure 4. Graphic representation of penetrability for the various forms of radioactivity.

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## 2. Distance and Radiation Intensity

Despite the fact that gamma rays and X-rays have longer range than other forms of radiation, distance still has a significant negative effect on their detectability. For an isotropic radioactive source where  $S$ : is the source strength at the origin,  $I$ : is the radiation intensity and  $r$ : is the distance from the source, we have

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<sup>260</sup> Source: Uranium Information Center as cited in Underground Bomb Shelter Planning, "Understanding Radiation," Underground Bomb Shelter, <http://www.undergroundbombshelter.com/bomb-shelter-planning.htm>.

$$(1.1) \quad I = \frac{S}{4\pi r^2}.$$

Therefore, the radiation intensity is inversely proportional to the square of the distance, or more simply put, as the distance away from the source doubles, triples, etc., the intensity of the remaining radiation that is available for detection subdivides respectively by a factor of four, nine, etc. This effect, visually represented in Figure 5, poses a severe restriction on the remote detection of radioactive materials.

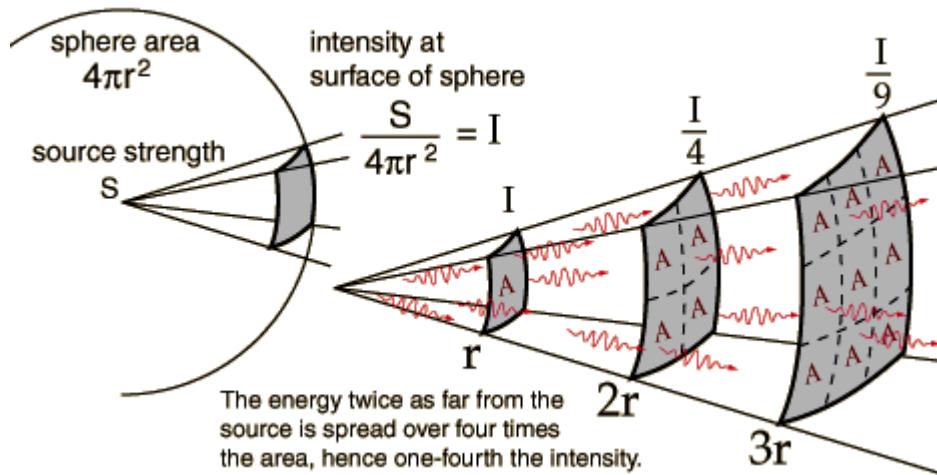


Figure 5. The effect of distance over radiation intensity.<sup>261</sup>

The last two factors that determine the response of a sensor to a given radioactive source, namely, the solid angle of view and time, will be discussed in sections E.(b) *Detector Counting Efficiency* and E.(c) *ARAM theoretical counting rate*.

## B. SCINTILLATION DETECTORS

Regardless of the amount of energy available for detection at a given distance, in order for gamma rays or X-rays to actually be detected, their energy must be converted to another measurable form, namely an electric current, a chemical change, or a light pulse.

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<sup>261</sup> Lawrence W. Fisher, *Selection of engineering materials and adhesives* (Boca Raton, FL: Taylor & Francis, c2005), 121.

The first two forms of measurement offer certain advantages, such as great accuracy and great efficiency for low energy X-rays. For more general use, these approaches have significant drawbacks, mostly related to technical limitations. A gamma detector, due to the distance effect, needs to make maximum use of the photons that reach the detector. This can best be accomplished through the use of dense detectors with large volumes. Currently, the most efficient detectors satisfying these preconditions are the ones based on the scintillation operating principle, i.e., the conversion of gamma ray and X-ray energy to a light pulse. Typically, the expected range of these photons lies within the energy range of 5 keV to 5 MeV.<sup>262</sup> A basic diagram of a scintillation detector, corresponding well with the gamma detector configuration used by the ARAM system, is shown in Figure 6.

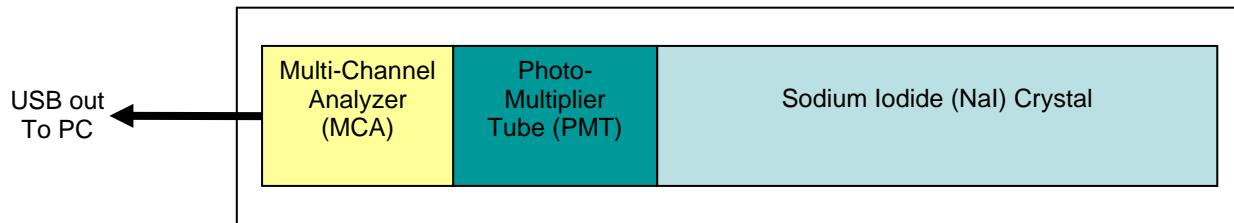


Figure 6. Gamma detector configuration used by the ARAM system.<sup>263</sup>

The use of crystalline sodium iodide (NaI) marked a breakthrough in scintillation detection technology as early as 1948, and after six decades NaI is still considered “the standard scintillation material,” largely due to its properties of being machinable into a broad variety of sizes/shapes, as well as having an excellent light yield.<sup>264</sup> This light output is in turn converted into an electron flux, i.e. an electric current, by the Photo-Multiplier Tube (PMT), a type of vacuum tube that also contributes to the detection process by proportionally amplifying these current pulses prior to their entry into the next stage of the detector, the multi-channel analyzer (MCA). There, the voltage amplitude, proportionally corresponding to the gamma ray and X-ray photons’ energies collected by

<sup>262</sup> Saint-Gobain Crystals’ Library Technical Information Notes, “Measuring Radiation: An Introductory discussion,” Saint-Gobain Crystals’ Library, 2, [http://www.detectors.saint-gobain.com/Media/Documents/S00000000000000001004/SGC\\_Measuring\\_Radiation.pdf](http://www.detectors.saint-gobain.com/Media/Documents/S00000000000000001004/SGC_Measuring_Radiation.pdf).

<sup>263</sup> Source: Textron Systems.

<sup>264</sup> Knoll, *Radiation detection and measurement*, 234-236.

the NaI crystal, is accurately measured and allocated into memory bins. Over time, a series of photons is collected, of which, after being converted to current pulses, the total counts and energies are stored in the MCA. The final output of the MCA is the so-called “spectrum,” a histogram of counts versus energies. This spectrum sets the basis for any further computer analysis in order to determine whether the collected data sufficiently exceeds background levels to signify the detection of a radioactive material. If this is the case, the MCA will further identify the radiation source through analysis of its spectral signature, an analysis generally referred to as spectroscopy.

### C. GAMMA/X-RAY INTERACTIONS AND SPECTROSCOPY

Each radionuclide decays by emitting a specific combination of particles and discrete photons. For example,  $^{137}\text{Cs}$  emits a 662 keV gamma photon, a 32 keV X-ray photon and a beta particle.<sup>265</sup> However, alpha and beta particles, due to their weak penetrating capability, cannot get through the NaI crystal housing and therefore do not have any scintillation effect, even if the detector is very close to the source. X- and gamma rays, on the other, produce a measurable spectrum mainly through three mechanisms of interaction with matter: photoelectric absorption, Compton scattering, and pair production. Generally, for NaI detectors, the photoelectric absorption is the “predominant” interaction mechanism for incident photons energies ranging within  $0 \leq E_i \leq 100$  keV. Compton scattering starts having a significant effect on the spectrum (i.e., the creation of a Compton continuum in addition to photopeaks), only for gamma photons of 100keV energy or more, while pair production effect is negligible for photons below 2 MeV.<sup>266</sup>

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<sup>265</sup> Saint-Gobain Crystals’ Library Technical Information Notes, “Measuring Radiation: An Introductory discussion,” 4.

<sup>266</sup> Saint-Gobain Crystals’ Library Technical Information Notes, “Efficiency Calculations for Selected Scintillators,” Saint-Gobain Crystals’ Library. [http://www.detectors.saint-gobain.com/Media/Documents/S0000000000000001004/SGC\\_Efficiency\\_Calculations.pdf](http://www.detectors.saint-gobain.com/Media/Documents/S0000000000000001004/SGC_Efficiency_Calculations.pdf).

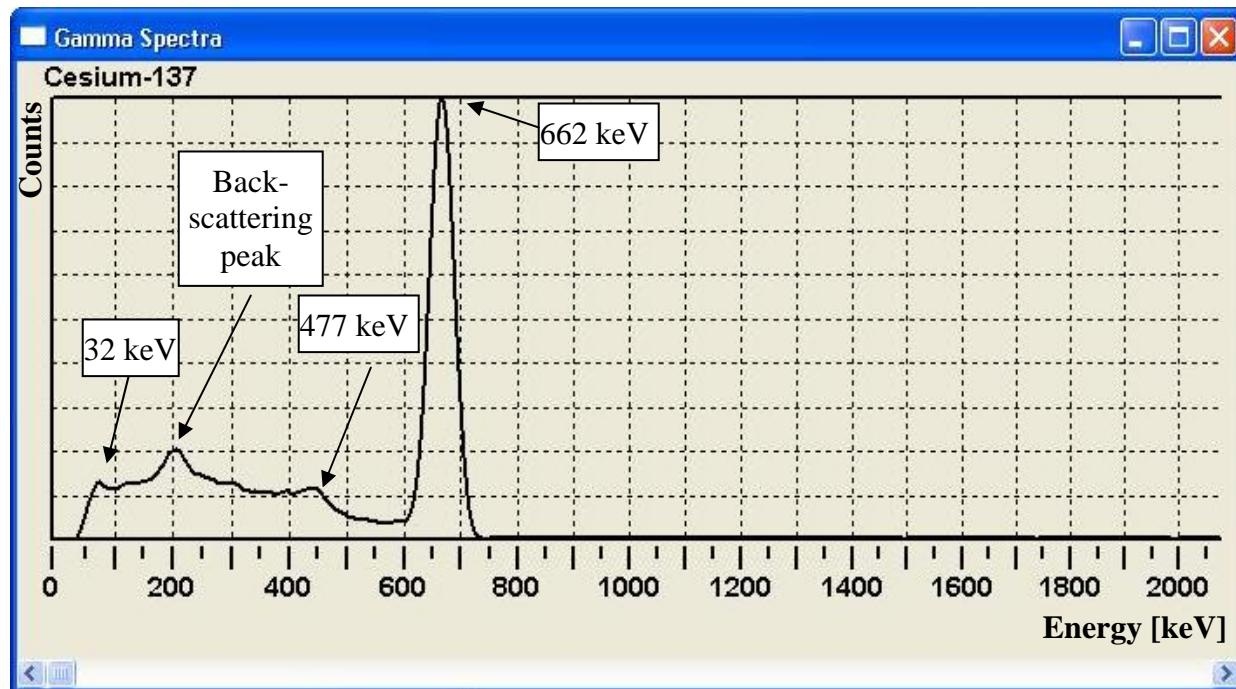


Figure 7. Gamma signature of  $^{137}\text{Cs}$ .<sup>267</sup>

### 1. Photoelectric Absorption

Figure 7 shows the typical  $^{137}\text{Cs}$  spectrum as obtained by ARAM. In this plot, photons of energies 662 keV and 32 keV are represented as peaks, or photopeaks. These peaks are characteristic of photoelectric absorption resulting from the characteristic radiation of  $^{137}\text{Cs}$  decay. During the phenomenon of photoelectric absorption, the colliding photon passes most of its energy to a single electron, which is then liberated from the crystal bond while, in parallel, the original binding energy of the electron is transferred to other secondary/lower energy electrons that are also liberated. The sum of all these moving electrons produces scintillation light within the NaI crystal. Photoelectric absorption is regarded as the ideal interaction in spectroscopy, because the

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<sup>267</sup> Source: Textron Systems.

incident photon is fully absorbed by the crystal. Therefore, the MCA would count only discrete energy values (662 keV and 32 keV in the case of  $^{137}\text{Cs}$ ), giving a spectrum of similarly discrete peaks (delta functions).<sup>268</sup>

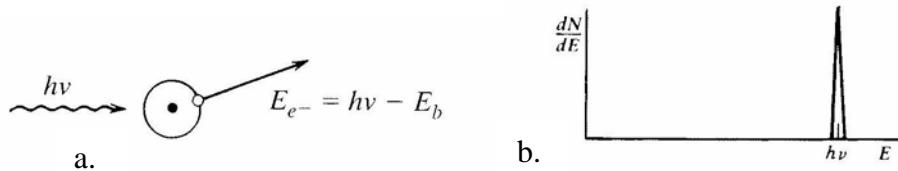


Figure 8. a. Sketch of a photoelectric absorption interaction and b. Graphic distribution of the electron energy over a series of similar events (delta function).<sup>269</sup>

## 2. Compton Scattering

However, the spectrum of Figure 7 consists of more than these photopeaks and its apparent complexity is indicative of the presence of other interaction processes. Thus, the continuum between 32 and 477 keV is called the Compton continuum and is a result of Compton scattering, portrayed in Figure 9.

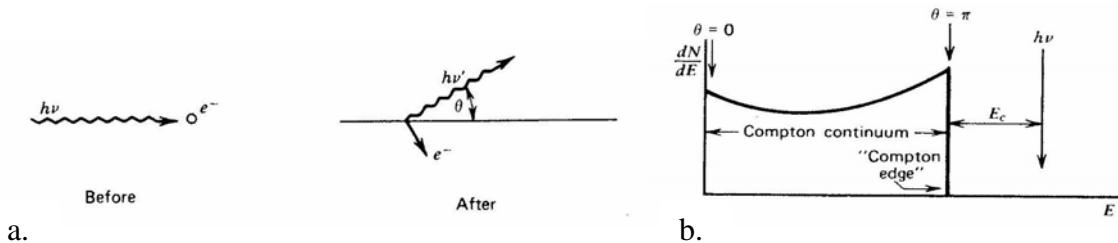


Figure 9. a. Sketch of a Compton scattering interaction and b. Graphic distribution of the electron energy over a series of similar events (Compton continuum).<sup>270</sup>

Compton scattering occurs when a gamma ray interacts with an electron in the scattering medium (in this case, the NaI crystal), resulting in a scattered gamma ray and a recoil electron. By conservation of energy, the energy of the incident gamma photon ( $E_i$ ) is shared, after the interaction, between the scattered photon ( $E_s$ ) and the kinetic energy of

<sup>268</sup> Knoll, *Radiation detection and measurement*, 309; Saint-Gobain Crystals' Library Technical Information Notes, "Measuring Radiation: An Introductory discussion," 4.

<sup>269</sup> Source: Knoll, *Radiation detection and measurement*, 309.

<sup>270</sup> Source: Knoll, *Radiation detection and measurement*, 310.

the electron in a way that is dependant on the scattering angle  $\theta$ .<sup>271</sup> This dependence is described by the following formula.

$$(1.2) \quad E_s = \frac{E_i}{1 + E_i(1 - \cos \theta) / 511}, \text{ where the } E_i, E_s \text{ units are in keV.}$$

The case when  $\theta=180^0$ , i.e., when the gamma photon scatters back in the opposite direction, coincides with the maximum energy of the scattered photon, which for the 662 keV incident photon of  $^{137}\text{Cs}$  corresponds to  $E_s=477$  keV. As shown in Figures 7 and 9b this energy marks the end of the Compton continuum and for this reason is called the Compton edge. For all other cases of scattering angle  $0 \leq \theta < 180$ , the energy of the scattered photon being “deposited” into the NaI crystal will range between  $32\text{keV} \leq E_s < 477$  keV thus “drawing” the rest of the Compton continuum.<sup>272</sup>

The reason, though that the continuum does not appear to be smooth is due to another side effect called back-scattering. When deployed in the field, gamma detectors are receptive not only to the intended radioactive sources of interest, but also to the abundance of background sources including cosmic radiation and other terrestrial radioactive sources that are widespread in nature such as  $^{40}\text{K}$ . In order to minimize the impact of this ambient radiation noise and optimize the detector’s field of view, gamma detectors are surrounded by lead shielding in all directions except the viewing direction of the detector. This kind of shielding, and to a lesser degree the overall metal housing of the detector and other adjacent materials, may cause a signal in the detector that is similar to the Compton scattering of photons, called back-scattering. Some of the photons from this back-scattering will eventually end up into the NaI crystal leading, for the case of  $^{137}\text{Cs}$ , to the back-scattering peak near 185keV,<sup>273</sup> as represented in Figure 7. A visual representation of the back-scattering process is shown in Figure 10.

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<sup>271</sup> Knoll, *Radiation detection and measurement*, 310.

<sup>272</sup> Saint-Gobain Crystals’ Library Technical Information Notes, “Measuring Radiation: An Introductory discussion,” 4.

<sup>273</sup> Saint-Gobain Crystals’ Library Technical Information Notes, “Measuring Radiation: An Introductory discussion,” 4.

## Scintillation: How the Detector Works

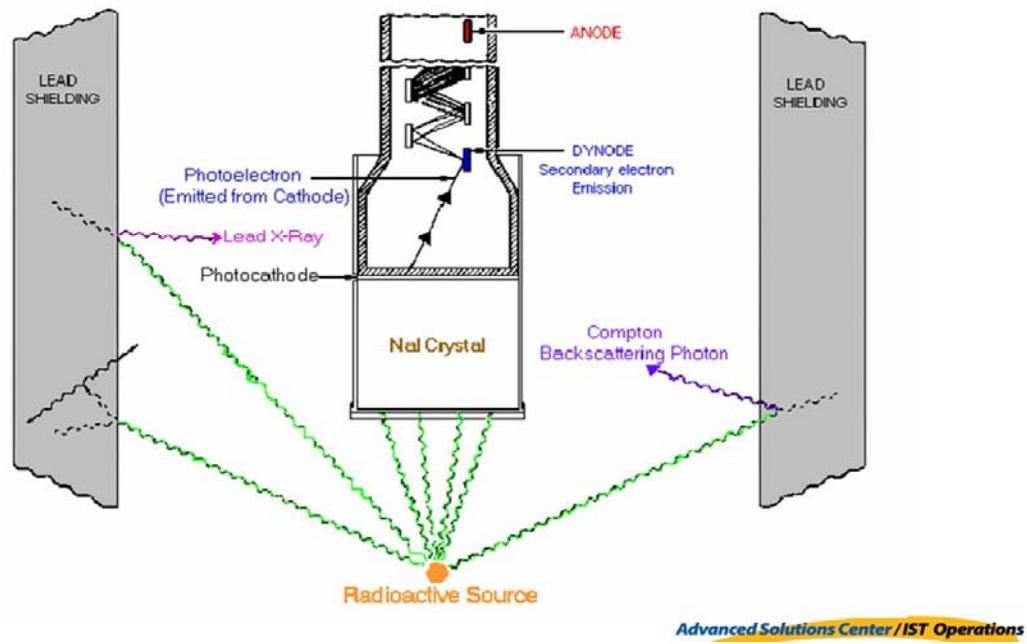


Figure 10. Detailed gamma detector configuration and visualization of the various gamma photon paths (direct and Compton back-scattering).<sup>274</sup>

### 3. Pair Production

The last gamma ray interaction with matter is pair production, referring to the production of an electron-positron pair (matter-antimatter pair) at the point when a high energy incident gamma photon becomes completely absorbed by the NaI crystal. “High” energy is understood to be energy above  $1022\text{keV} = 2m_o c^2$ , this being the threshold for the creation of an electron-positron pair. When this threshold is exceeded by the incident photon, then the surplus of energy is passed onto the pair in the form of kinetic energy equal to the energy deposited on the crystal and given by the formula:

$$(1.3) \quad E_{kinetic} = E_{e^-} + E_{e^+} = E_i - 1022\text{keV}$$

<sup>274</sup> Source: Textron Systems.

However, the positron is an unstable particle which will eventually collide with an electron and annihilate into two equal 511 keV photons, going away from each other in opposite directions. Depending on the dimensions of the NaI crystal, none (in the case of small detectors), one, or both of these photons (in the case of large detectors) will eventually further interact in photopeak absorption or Compton scattering with the crystal, thus depositing additional energy and potentially leading to the so-called “single” or “double escape peaks.”<sup>275</sup>

Although further analysis of these interactions is beyond the scope of this thesis, this background is regarded as essential for the evaluation of detector systems such as ARAM, since both detection and identification of radioactive sources are based on peak identifications algorithms and spectra comparisons.

#### **D. BACKGROUND NOISE, CALIBRATION, DETECTION, AND IDENTIFICATION**

As aforementioned, the omnipresence of terrestrial and cosmic radioactivity makes it necessary to define what constitutes “normal activity” (e.g., the radiation field that would be expected due to cosmic radiation and naturally occurring radioactive materials) at a given location of measurement, in order to detect the real sources of interest. This natural activity is defined as the background, a typical depiction of which is shown in Figure 11.

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<sup>275</sup> Knoll, *Radiation detection and measurement*, 312-317; Saint-Gobain Crystals’ Library Technical Information Notes, “Measuring Radiation: An Introductory discussion,” 4.

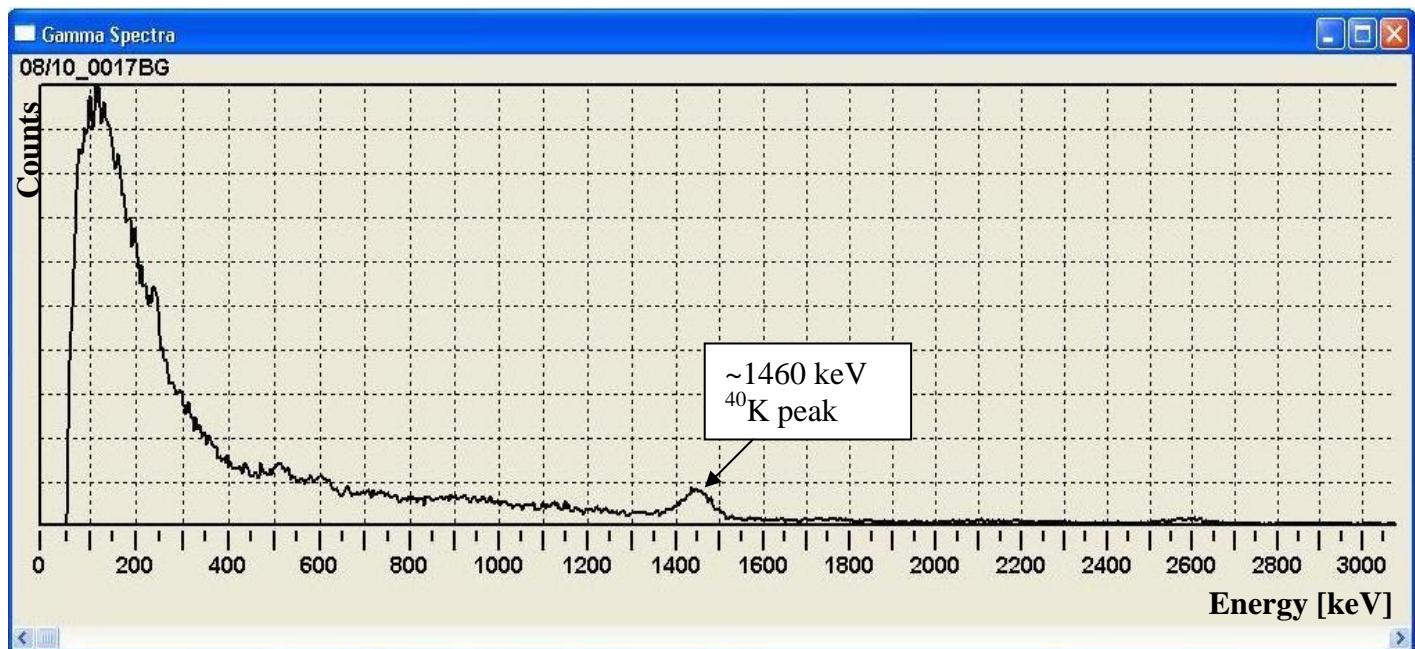


Figure 11. Typical gamma background spectra.<sup>276</sup>

Determination of the background spectrum is very important in radiation detection. First, it is used as the basis for system calibration. When an unknown source needs to be detected, which will always be the case in maritime interdictions, an energy point of reference must be established to assure accurate spectrum measurements. This is achieved by seeking the photopeaks of known, omnipresent sources and by attributing to them the already known energy value. One of the most commonly used is the characteristic 1460 keV  $^{40}\text{K}$  peak,<sup>277</sup> as shown in Figure 11. Apart from this useful aspect, though, background noise has primarily negative effects in radiation detection, by potentially masking sources of interest especially in the low end of the spectrum. Thus, lead shielding of detectors is used to block background radiation as completely as possible without interfering with the detector's desired field of view.

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<sup>276</sup> This terrestrial background spectrum was measured by the ARAM system at Textron Systems, IST Operations facilities in Goleta, near Santa Barbara, CA. Source: Textron Systems.

<sup>277</sup>  $^{40}\text{K}$  is a ubiquitous naturally occurring radionuclide that has a half-life of  $1.28 \times 10^9$  years and decays by beta decay 89.3% of the time with maximum beta energy of 1.31 MeV and electron capture 10.7% of the time with an associated gamma ray of 1460 keV.

Nevertheless, since background counts cannot be fully eliminated by shielding, the remaining background level is subtracted from actual measurements with the use of software. The result of this background subtraction is the measured signal above the noise and this determines whether or not the source can be detected. With a threshold allowing for random, statistical fluctuations of the continuously changing background, any remaining difference in counts signifies the presence/detection of a radioactive material. Nevertheless, mere detection of the presence of “abnormal” levels of radioactivity is only the first step. If there is sufficient information in the signal, it is also possible to determine the actual material that is the source of the signal. The difference between the measured signal and the background spectrum can be further analyzed by software applications that consist of peak search algorithms to identify peaks in the measurement. Identified peaks are then compared with a library of spectra representing the full range of possible radioactive materials, such as  $^{137}\text{Cs}$  whose gamma spectra are shown in Figure 7; this process leads to the identification of the radioactive material. The gamma spectra of Figure 12 show a comparison of maritime interdiction signature (black), background (red), and library (green).

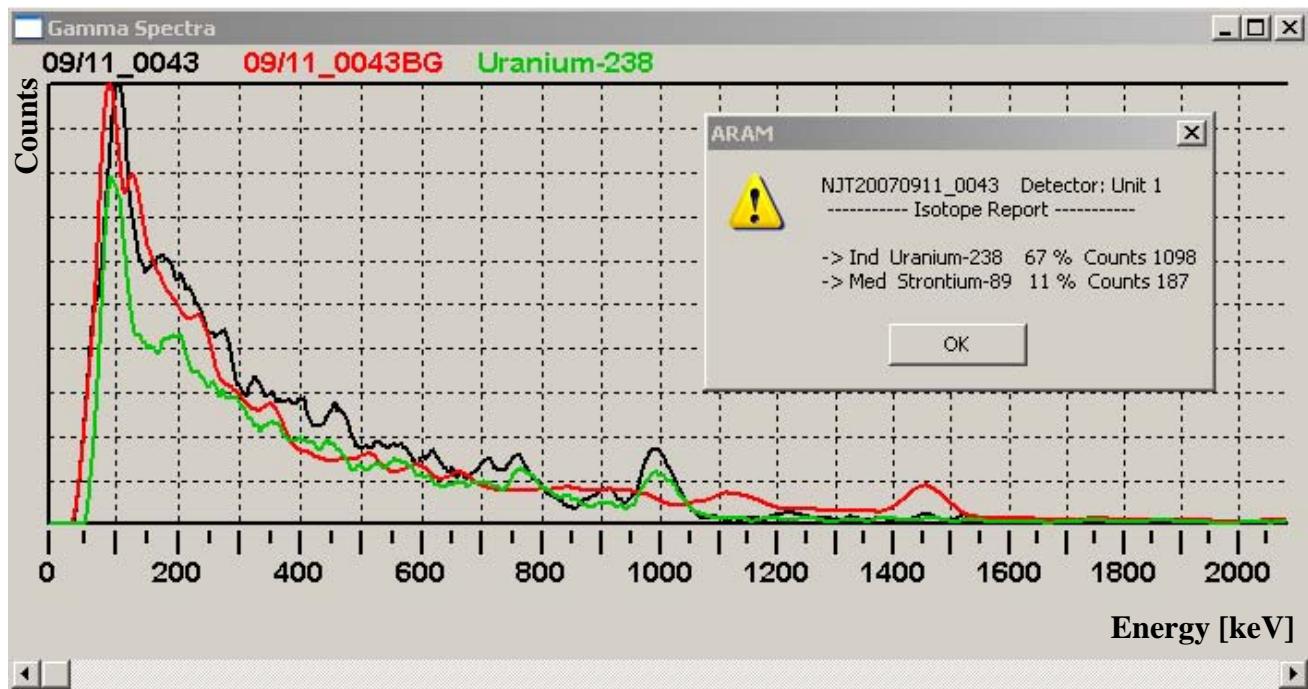


Figure 12. Gamma spectra comparison of maritime interdiction signature (black), background (red), and library (green).<sup>278</sup>

#### E. EVALUATION OF THE ARAM SYSTEM

The evaluation of the ARAM gamma detector performance was conducted in two ways; first, theoretically, by determining its counting efficiency in a maritime scenario and second, by taking measurements in both maritime as well as laboratory environments. These measurements were conducted at the Textron Defense Systems facilities near Santa Barbara, California, during the period April 16 to April 18, 2008. In the following analysis, the operational and performance requirements are in accordance with the American National Standard Performance Criteria for Mobile and Transportable Radiation Monitors Used for Homeland Security,<sup>279</sup> the equations and theoretical set up are based on Saint-Gobain Crystals' Library Technical Information Notes regarding

<sup>278</sup> Source: Textron Systems Proprietary, "Adaptable Radiation Area Monitor (ARAM) – A Portal Monitor for the Detection of Illicit Nuclear Material," Textron Systems, March 31, 2008 (Goleta, CA).

<sup>279</sup> American National Standards Institute, Institute of Electrical and Electronics Engineers, and IEEE Xplore. *American National Standard Performance Criteria for Mobile and Transportable Radiation Monitors Used for Homeland Security*.

“Efficiency Calculations for Selected Scintillators,”<sup>280</sup> while the relevant Matlab program generating theoretical counts is based on data provided by Textron Systems Principal Engineer Tom Saunders.<sup>281</sup>

## **1. Operational and Performance Requirements**

Before laying down these requirements, it is necessary to point out that even successful completion of the radiation tests described in the relevant ANSI standard, “should not be construed as an ability to successfully detect and identify all radionuclides in all environments.”<sup>282</sup>

For mobile monitors mounted on seagoing vessels, the concept of operations requires passes of the monitor in parallel tracks to a stationary source (or vice versa) with a speed of 8 km/h (2.24 m/sec) and at a parallax distance of 5 m.<sup>283</sup> Although the ANSI procedure mentions several different radionuclides to be used for technology demonstration trials, due to time and other field constraints, only three sources were adequately tested during the actual maritime exercise and only those will be reported henceforth; <sup>133</sup>Ba, <sup>137</sup>Cs and <sup>60</sup>Co. The ANSI requirements for unshielded activity of these sources (i.e., the required source strength of the unshielded sources) are set respectively to 9, 20 and 7 [ $\mu$ Ci].<sup>284</sup>

## **2. Lake Cachuma Test**

In order to evaluate the performance of ARAM in a water environment, a test was conducted on Lake Cachuma, California, on April 18, 2008. This test was a mid-stage appraisal by Textron Systems with the purpose of optimizing the system prior to its participation in the extensive testing program called “Crawdad.” “Crawdad” was

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<sup>280</sup> Saint-Gobain Crystals’ Library Technical Information Notes, “Efficiency Calculations for Selected Scintillators.”

<sup>281</sup> Tom Saunders, e-mail message to author, May 12, 2008.

<sup>282</sup> American National Standards Institute, Institute of Electrical and Electronics Engineers, and IEEE Xplore. *American National Standard Performance Criteria for Mobile and Transportable Radiation Monitors Used for Homeland Security*, 1.

<sup>283</sup> Ibid., 12-13, 26-27.

<sup>284</sup> Ibid., 20.

launched during the summer of 2008 by the Savannah River National Laboratory; it involves the testing of radiation detectors mounted on maritime platforms and is closely related to the Department of Homeland Security's Small Vessel Security Strategy (SVSS).<sup>285</sup> The purpose of this strategy is “to reduce potential security and safety risks from small vessels through the adoption and implementation of a coherent system of regimes, awareness, and security operations that strike the proper balance between fundamental freedoms, adequate security, and continued economic stability.”<sup>286</sup> The term “small vessel” refers to a craft with displacement of 300 gross tons or less,<sup>287</sup> but nothing restricts the use of the relevant technology and means to vessels of greater tonnage. In such a case, the only impediments would be relevant to the decreased performance of the system due to the aggravated effects of distance and shielding, proportionate to the increased dimensions (distance) and multitude of compartments (shielding). According to testing program manager Matthew Graviss,<sup>288</sup> the strategic objective of “Crawdad” is to promote probable cause in maritime interdictions involving illicit nuclear and other radiological materials and prevent these materials from reaching the U.S., hence the objectives of “Crawdad” are highly pertinent to the scope of this thesis.

#### *a. Test*

The test at Lake Cachuma was conducted with two leisure boats, hereafter referred to as the sensor and target vessels, respectively. The ARAM configuration used consisted of two gamma detectors (2”x4”x16” in size) and one neutron detector (36”  $^3\text{He}$  tube) firmly placed in parallel with the sensor vessel’s longitudinal axis as visualized in Figure 13. A detail not included in Figure 13, due to lack of three-dimensional perspective, is that the target vessel had a lower freeboard than the sensor one, meaning

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<sup>285</sup> Haley Hughes, “Crawdad testing helps with radiation detection,” aikenstandard.com, August 14, 2008, <http://www.aikenstandard.com/0814SRS>.

<sup>286</sup> U.S. Department of Homeland Security, “Small Vessel Security Strategy,” U.S. Department of Homeland Security Library, April 2008, <http://www.dhs.gov/xlibrary/assets/small-vessel-security-strategy.pdf>, 1.

<sup>287</sup> Ibid.

<sup>288</sup> Rob Pavey, “Boat-mounted radiation detectors being tested at Savannah River Site: Tool against terrorists,” Online Athens Banner-Herald, August 13, 2008, [http://onlineathens.com/stories/081408/news\\_2008081400393.shtml](http://onlineathens.com/stories/081408/news_2008081400393.shtml).

that sensor and source had a vertical parallax separation of about 0.2m. The neutron detector, though properly connected to verify proper communication/operation, was not tested due to lack of a neutron emitter. In addition, the two gamma detectors were from two different suppliers, Alpha Spectra, Inc. Scintillation Detectors and Saint-Gobain Crystals, both using similar technology and a core of sodium iodide (NaI) crystal, but with different housings: 0.8mm of aluminum for the Alpha detector, versus 1mm of steel for the Saint-Gobain one.

During the test, the target boat remained virtually stopped (there was a slight drifting motion due to wind and current) while the sensor vessel conducted passes in parallel tracks and at various distances. During each pass the sensor boat's speed was kept fairly low at about 2 mph and between each pass the boat would recede to adequate distance in order not to let the test sources interfere with ARAM's detected background and become part of it (because of its small dwell time), which would result in reduced sensitivity. Also, to reduce background, the measurements were taken at locations with depths ranging from 130 to 140 ft and distances ranging from 200 to 400 m from the nearest shore. Nevertheless, background potassium levels remained at almost half of the respective terrestrial levels representing 500 to 700 counts per second.

*b. Detector Counting Efficiency*

Given the distance effect, propagation attenuation factors, and the complexity of interactions taking place inside the detector, only a small portion of the gamma rays emitted by a radioactive source will eventually produce a count in the system. The detector counting efficiency (DE) expresses exactly a theoretical calculation of this portion. The detector efficiency is very important in terms of performance evaluation because, as will be demonstrated, it can thereafter easily give the expected counting rate for a given source in a known geometry of transitory measurements, and thus provide a tangible index of ARAM's detection capabilities.

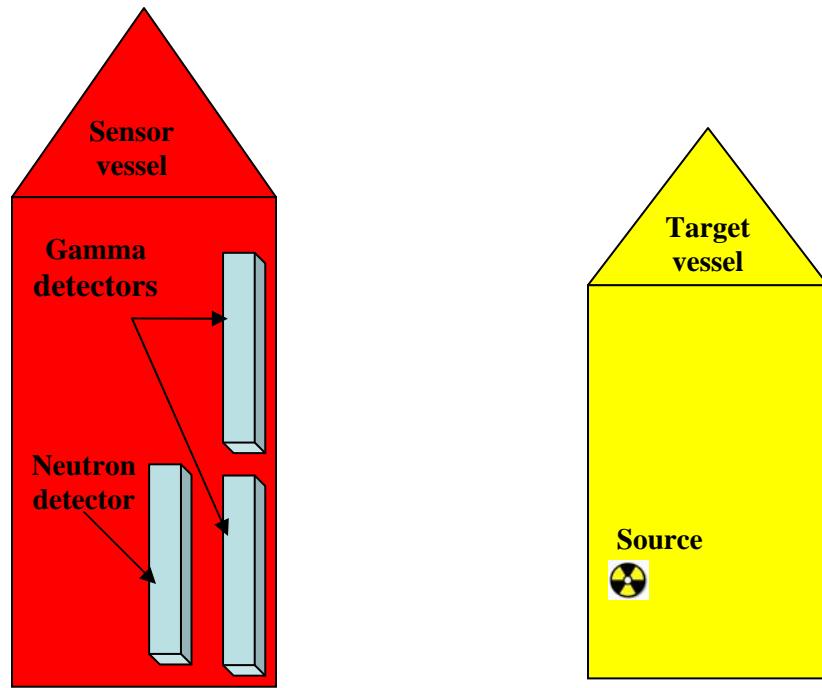


Figure 13. Boat Configuration For the Lake Cachuma Test.

$DE$  is given by the formula

$$(1.4) \quad DE = G * I * M, \text{ where}$$

$G$ : is the geometrical solid angle factor or in other words “the fraction of all space that the detector subtends.”<sup>289</sup> All space means the “area of sphere with a radius equal to the source detector distance.”<sup>290</sup> It is evident that in any real world scenario  $G \ll 1$ .

$I$ : is the propagation attenuation factor. During the propagation of gamma rays from the radioactive source to the actual NaI crystal, there are several intermediate materials, the presence of which, due to absorption or scattering, inflicts additional losses above those due to the distance effect. Thus, the  $I$  factor represents the fraction of the source-emitted photons that will eventually reach the scintillation crystal. Some of the

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<sup>289</sup> Saint-Gobain Crystals’ Library Technical Information Notes, “Efficiency Calculations for Selected Scintillators,” 3.

<sup>290</sup> Ibid.

typical intermediate materials along the ray path include the source's shielding, the atmospheric air, and the housing of the detector.

The general form of  $I$  to reflect attenuation caused by more than one material would be:

$$(1.5) \quad I = I_1 * I_2 * I_3 * \dots$$

Every elementary  $I_i$  is given by the formula:

$$(1.6) \quad I_i = e^{-\mu_i * d_i}, \text{ where}$$

$\mu_i$ : is the attenuation coefficient of the respective material and

$d_i$ : is the distance traveled through it by the gamma photons.

$M$ : is the “fraction of the photons absorbed by the detector.”

As previously described, gamma ray interactions with matter are fairly complicated and dependant to a large extent on the dimensions of the NaI crystal; the greater the dimensions, the greater the probability that a photon will interact with the crystal, deposit its energy, and give a count, instead of escaping undetected.

**c. ARAM Theoretical Counting Rate for American National Standard Transitory Measurements Geometry**

Assuming that “all photons are traversing the same amount of detector material,”<sup>291</sup> the area that each detector subtends relative to the source can be approximated by the face area  $S$  of the detector, which is

$$(1.7) \quad S = 4'' * 16'' = 0.04129 m^2$$

Therefore, one can define the theoretical counting rate,  $G$ , by

$$(1.8) \quad G = \frac{S}{4\pi d^2}, \text{ where } d: \text{ is the distance between the source and the}$$

detector.

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<sup>291</sup> Saint-Gobain Crystals' Library Technical Information Notes, “Efficiency Calculations for Selected Scintillators,” 4.

However, due to the transitory measurements geometry,  $d$  is not fixed, but a function of time. If  $z$  is the vertical axis,  $x$  is the sensor boat axis of motion and  $y$  is their complimentary axis, then:

$$(1.9) \quad x = x_0 + v * t, \quad y = 5 \text{ and } z = 0.2 \text{ and}$$

$$(1.10) \quad d = \sqrt{x^2 + y^2 + z^2} = f(t)$$

Regarding the calculation of the propagation attenuation factor  $I$ , the sources were not shielded, thus the only coefficients to be used are:

$$(1.11) \quad \mu_{air} = 1.3 * 10^{-3} * E_{\gamma}^{-0.4148} \text{ cm}^{-1} : \text{attenuation coefficient of air.}$$

$$(1.12) \quad \mu_{Al} = 5.97 * E_{\gamma}^{-0.5249} \text{ cm}^{-1} : \text{attenuation coefficient of the aluminum housing for the Alpha Spectra detector.}$$

$$(1.13) \quad \mu_{Fe} = 225.16 * E_{\gamma}^{-0.8933} \text{ cm}^{-1} : \text{attenuation coefficient of stainless steel housing for the Saint-Gobain detector.}$$

All these attenuation coefficients are dependant upon the respective gamma photons' energies  $E_{\gamma}$  for each radioactive source, while the distances travelled within each medium are  $d_{air}=d$ ,  $d_{Al}=0.8\text{mm}$  and  $d_{Fe}=1\text{mm}$ .

Last, the NaI crystal absorption efficiency  $M$  is given by:

$$(1.14) \quad M = 0.9869 * e^{-2.69 * 10^{-4} * E_{\gamma}}$$

With the detector efficiency  $DE$  known, the expected number of counts  $P$  is given by the product:

$$(1.15) \quad P = DE * N, \text{ where}$$

$$(1.16) \quad N = TB * T * A, \text{ and}$$

$TB$ : is the total branching ratio referring to a specific mode of decay and then on to a specific photon energy for that mode. Branching ratios are “the probabilities of various de-excitation transitions;”<sup>292</sup> e.g., there is an 85% probability that the excited nuclei of <sup>137</sup>Cs will emit a 662 keV gamma photon during its transition to the daughter product of <sup>137</sup>Ba. On the other hand, the decay scheme of <sup>60</sup>Co consists of a beta particle emission followed, at 99.97% of the time, by an 1173 keV gamma ray to a still excited

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<sup>292</sup> Knoll, *Radiation detection and measurement*, 11.

state, and then by a 1332 keV gamma photon with a similarly high branching ratio of almost 100%.<sup>293</sup> The decay schemes of both the aforementioned sources are portrayed in Figure 14.

*T*: “the total counting time interval;”

*A*: the activity of the radioactive source expressed in disintegrations per second (dps); and

*N*: the aggregate number of photons emitted by the source during the time interval *T*.

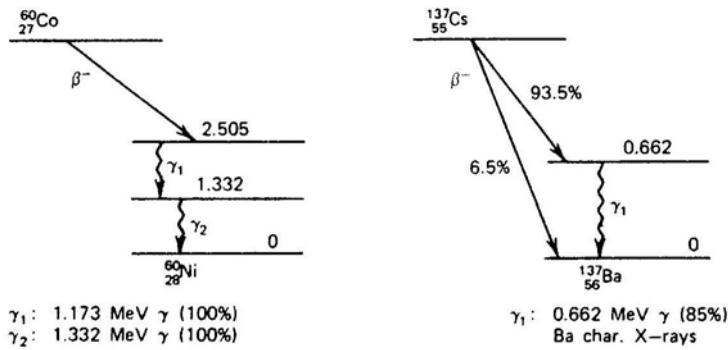


Figure 14. Decay schemes of  $^{60}\text{Co}$  and  $^{137}\text{Cs}$ .<sup>294</sup>

Due to the complexity and multitude of these calculations, a Matlab program was constructed to extract the expected number of counts *P*, making use of the theoretical equations set up above, as well as the activities, gamma photon energies, and branching ratios data of the tested sources given in Table 2.

<sup>293</sup> Knoll, *Radiation detection and measurement*, 11.

<sup>294</sup> Source: Knoll, *Radiation detection and measurement*, 11.

Table 2. Gamma Photon Energies and Respective Branching Ratios (*BR*) for Each Tested Source.

Source	Activity [ $\mu$ Ci]	$E_\gamma$ [keV]	<i>TB</i> [%]								
$^{133}\text{Ba}$	9	80.99	25	276.4	5.6	302.85	14.3	356.01	48.1	383.85	6.9
$^{137}\text{Cs}$	16	661.66	84.62								
$^{60}\text{Co}$	7	1173.24	99.97	1332.5	99.98						

Table 3 demonstrates the results of the Matlab program. Due to the different housing of the Alpha Spectra and Saint-Gobain detectors, their outcomes are shown separately, while a third column gives their sum of counts, representing the anticipated performance of the ARAM system as a whole.

Table 3. Theoretical counting rate of each detector and ARAM as a whole in relation to the various test sources.

Nuclide	Activity [ $\mu$ Ci]	Alpha Counts	Saint-Gobain Counts	Total ARAM counts
$^{133}\text{Ba}$	9	189.2	159.2	348
$^{137}\text{Cs}$	16	279.2	263.5	543
$^{60}\text{Co}$	7	254.1	246.2	500

The validity of these theoretical results was then tested with the field measurements taken at Lake Cachuma. The measurements, however, were taken at various distances, in order to check the system limits in detection and identification for sources of different activities than the nominal ones in the ANSI N42.43-2006 and for a passing speed of 2 mph. Nevertheless, by means of averaging distances and in order to maintain a common reference of analysis, field measurements were subsequently reduced to the prompt standardization requirements, as shown in Table 4.

Table 4. Reduction table of the actual field measurements to the ANSI N42.43-2006 requirements.

Nuclide	Actual Activity [ $\mu\text{Ci}$ ]	N42.43 Activity unshielded [ $\mu\text{Ci}$ ]	Average Field Counts*Distance $^2$	Counts at 5 m	Counts at N42.43 activity	Final Counts at 5 MPH	Std Dev	Theoretical Counts
$^{133}\text{Ba}$	57	9	168502	$[\frac{1}{5^2}]$ 6740	$[\frac{9}{57}]$ 1064	$[\frac{2}{5}]$ 425	186	348
$^{137}\text{Cs}$	18.5	16	11416	457	395	158	109	543
$^{60}\text{Co}$	4.7	7	10687	427	636	254	123	500

Note: The bracketed factors in the Ba-133 row demonstrate how the respective counts were derived from the previous column. Similarly for the other two sources.

At this point it should also be noted that, apart from the aforementioned industrial isotopes, test measurements were also taken for source materials, namely  $^{232}\text{Th}$  and  $^{238}\text{U}$ . However, in an e-mail message to the author on April 30, 2008, Textron Systems Principal Engineer Tom Saunders commented that an analysis similar to the above of the  $^{232}\text{Th}$  and  $^{238}\text{U}$  test cases could not be performed because their activity was not known and a more complex theoretical set-up was required. The ability of ARAM to detect and identify the most important category of potentially illicit radionuclides according to the classification described in Chapter II, Special Nuclear Materials, was not included in these tests.

Despite the fact that such ability is regarded as “the most critical task for a spectroscopic portal monitor,” actual testing is largely unfeasible due to the strict regulatory control over the materials in question and subsequent limited access to them. Credible prediction models to test the peak identification algorithms used by ARAM can however be attained with statistical analysis. A Monte-Carlo study has shown that  $^{232}\text{Th}$ ,

HEU,  $^{238}\text{U}$ ,<sup>295</sup> and  $^{239}\text{Pu}$  all have approximately the same difficulty of identification.<sup>296</sup> The counts required for proper identification (i.e. 90% confidence accuracy over 1000 test runs) at maritime background levels are 750. The same study showed that the industrial isotopes of  $^{137}\text{Cs}$  and  $^{133}\text{Ba}$  can effectively mask low detection levels of HEU and WGPU (weapons grade plutonium) respectively. More specifically, the 185 keV back-scattering peak of  $^{137}\text{Cs}$  may interfere with the peak identification algorithms due to its close proximity to the  $^{235}\text{U}$  photopeak of 186 keV. Overall, “the identification accuracy of HEU was degraded as the level of  $^{137}\text{Cs}$  increased,”<sup>297</sup> with similar effects being expected for the combination of  $^{133}\text{Ba}$  and WGPU. The ARAM used peak search algorithms that were less susceptible to this kind of masking than their other significant counterpart of spectral template matching.<sup>298</sup>

*d. Conclusions-Recommendations for Lake Cachuma Test*

(1) Due to the thinner and less dense material housing (0.5mm of aluminium versus 1mm of stainless steel), the Alpha Spectra detectors’ performance was better than their Saint-Gobain counterparts. Thus, the housing of the detector along its field of view sides should have the lowest attenuation coefficient possible, by using only thin layers of non-dense materials.

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<sup>295</sup> Uranium ore consists mainly of  $^{238}\text{U}$  and to a far lesser extent,  $^{235}\text{U}$ . The process used to increase the amount of  $^{235}\text{U}$  relative to  $^{238}\text{U}$  is known as uranium enrichment. “U.S. civilian power plants typically use 3 to 5%  $^{235}\text{U}$ . Weapons use highly enriched uranium (HEU) with over 90 percent  $^{235}\text{U}$ . Some research reactors and all U.S. naval reactors also use HEU.” See Institute for Energy and Environmental Research Publications, “Uranium: Its Uses and Hazards,” Institute for Energy and Environmental Research, <http://www.ieer.org/factsheet/uranium.html>.

<sup>296</sup> Saunders, “Spectroscopic portal identification of special nuclear materials,” 1209-1211.

<sup>297</sup> Ibid.

<sup>298</sup> Saunders, “Spectroscopic portal identification of special nuclear materials,” 1209-1211.

(2) ARAM was initially developed for use in the terrestrial environment with fixed check-points of commercial traffic.<sup>299</sup> As a result, a number of its software and hardware configuration settings needed to be modified to meet the requirements of maritime application.

(a) Matlab theoretical values indicated that an event should be generated by the test conditions since 350 to 500 counts would be expected to be generated by a pass at 5 mph. This expectation was not verified by the Lake Cachuma tests for <sup>137</sup>Cs and <sup>60</sup>Co. It was clear as a result that the Sequential Probability Ratio Test (SPRT) B value should be lowered.<sup>300</sup>

(b) During the test, there were also an unusually high number of suppressed events, indicating that the detection threshold set within the ARAM systems may have been too high. The usual threshold values are based on terrestrial background and it is likely that this need for adjustment was a result of the lower background rates encountered in the maritime environment.

(c) Detection and identification may be improved by optimizing the lead shield configuration. Once again, the current configuration is optimized for terrestrial radiation, not maritime radiation.

(d) Last, in order to achieve 750 counts, corresponding to 90% identification accuracy, of <sup>232</sup>Th, HEU, <sup>238</sup>U, and <sup>239</sup>Pu will require at least three detectors.

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299 “ARAM has been deployed by the State of California since December 2004, scanning over 8,000 commercial trucks per day at the state’s border crossings to protect against incoming dirty bombs and other radiological weapons of mass destruction.” Source: Textron Systems Proprietary, “Adaptable Radiation Area Monitor (ARAM) – A Portal Monitor for the Detection of Illicit Nuclear Material,” Textron Systems, March 31, 2008 (Goleta, CA).

300 The Sequential Probability Ratio Test (SPRT) is one of the “statistical tests applied to make a trigger determination. [...] It is a Bayesian technique that provides added sensitivity over the traditional single-interval test (SIT). SPRT is able to reliably detect sources travelling at a much wider range of speeds than SIT. It also provides an “all clear” indicator as soon as SPRT is able to determine with sufficient confidence that the radiation in view is within acceptable limits from the background level.” Source: Textron Systems Proprietary, “Adaptable Radiation Area Monitor (ARAM) – A Portal Monitor for the Detection of Illicit Nuclear Material,” Textron Systems, March 31, 2008 (Goleta, CA).

## F. LAB MEASUREMENTS

In addition to the field test on Lake Cachuma, several test measurements were taken in the lab, mainly for  $^{137}\text{Cs}$  and  $^{232}\text{Th}$ . The activities of both sources used were similar to each other and approximately 10 measurements were taken at each distance; more measurements were taken at greater distances in order to extract safer conclusions concerning the range limits in detection and identification of each source. Background noise level fluctuated between 1225 and 1430 cps, far greater than the levels observed on Lake Cachuma. The ARAM performance was also proportionally degraded, despite the fact that this time the geometry was fixed (both detector and source were stationary). The results of these measurements are shown in Figures 14 and 15.

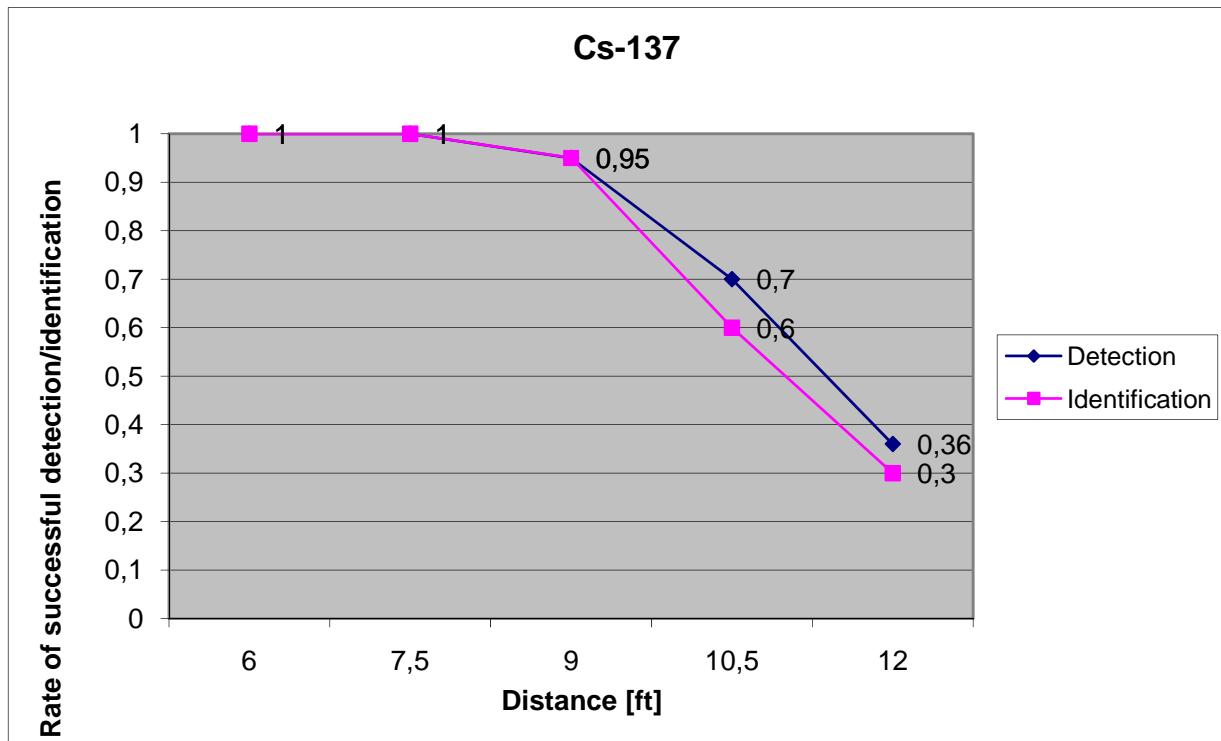


Figure 15. ARAM performance during lab measurements for  $^{137}\text{Cs}$ .

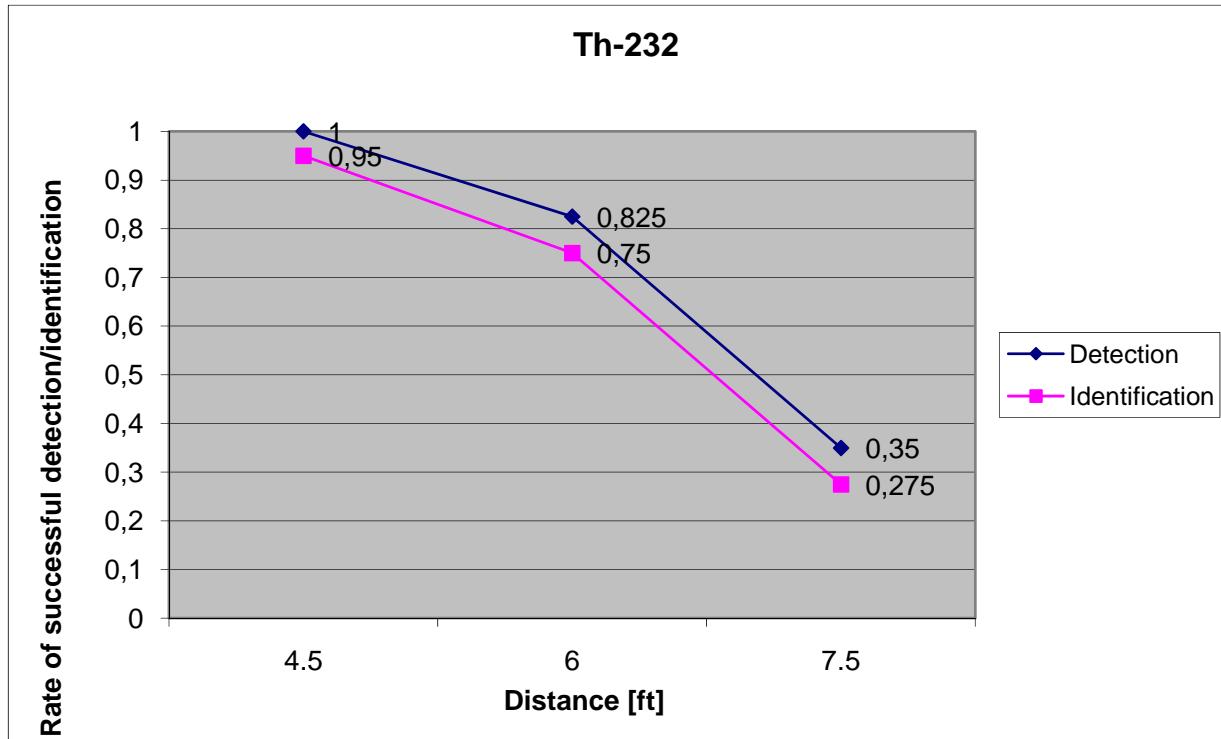


Figure 16. ARAM performance during lab measurements for  $^{232}\text{Th}$ .

From these diagrams, two qualitative conclusions can be extracted. At first glance it is obvious that though the number of counts generated at the portal may suffice to acquire a detection event, this is not always the case for identification too. The confidence level of the latter measurement seems to “lag” five to ten percent behind the one of detection throughout most tested ranges. This is to be expected since detection should be easier than identification in virtually every situation.

The second conclusion is that radionuclides that have their characteristic peaks concentrated at the lower end of the spectrum are harder to detect at greater distances. This conclusion could also be theoretically anticipated if the equations (1.11) to (1.13) were correlated with the library spectra of  $^{137}\text{Cs}$  (Figure 7) and  $^{232}\text{Th}$  (Figure 16). The 240 keV peak of  $^{232}\text{Th}$ , contributing the overwhelming majority of photons that will most probably generate counts for detection (due to photoelectric absorption, when photons fully deposit their energy to the NaI crystal) and being the most characteristic for

identification by the peak search algorithms, is at the same time more susceptible to propagation losses. (Lower gamma energies  $E_\gamma$  bring on greater attenuation coefficients  $\mu_i$ ). This is why ARAM's performance figures for  $^{137}\text{Cs}$  are degraded in terms of distance by approximately 4.5 ft in comparison with those of  $^{232}\text{Th}$ .

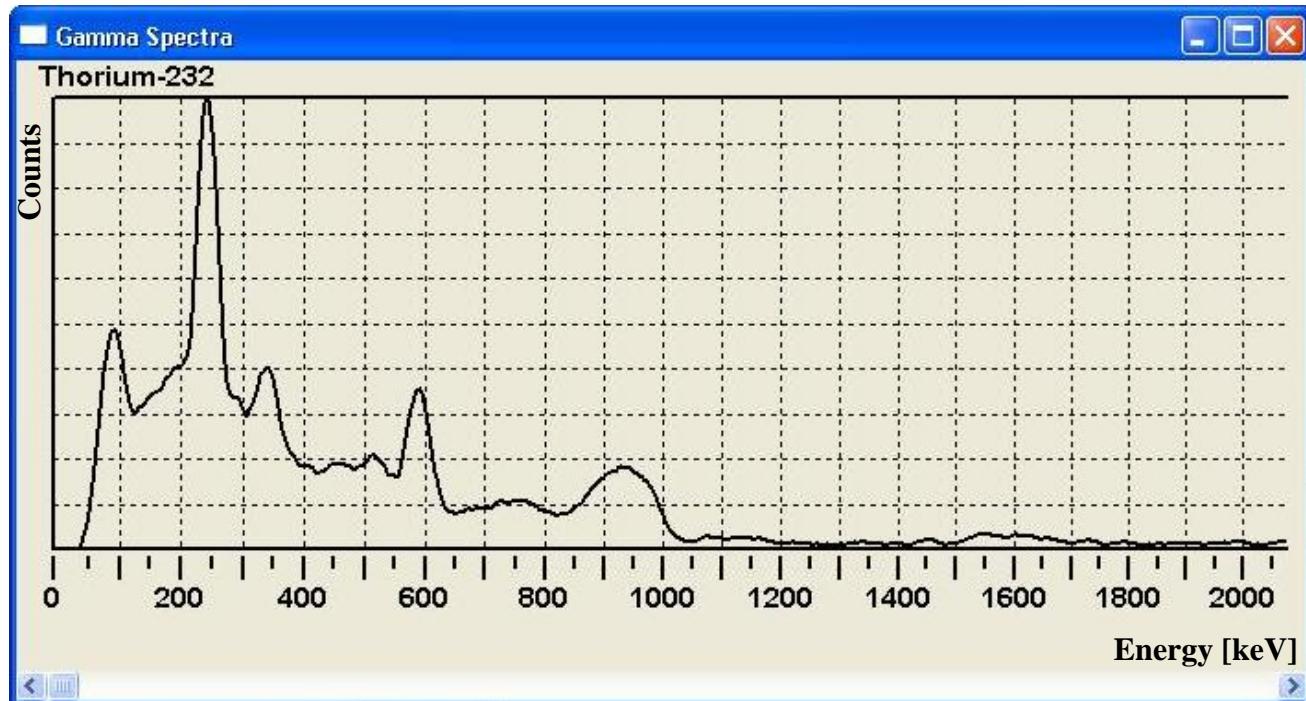


Figure 17. Gamma signature of  $^{232}\text{Th}$ .<sup>301</sup>

Similar results could also be expected for  $^{235}\text{U}$ , for which the two characteristic peaks reflect the emission of low energy gamma rays at approximately 98 keV and 186 keV. These photons present limited penetrability though most common materials, and therefore make uranium detection more difficult and more susceptible to shielding. More specifically, even a relative comparison of the shielding effect between these two gamma rays is revealing. A study has shown that while the presence of 5 mm steel shielding reduces "the 186 keV intensity by a factor of two, it reduces the 98 keV line by a factor of four."<sup>302</sup>

<sup>301</sup> Source: Textron Systems.

<sup>302</sup> K. J. Hofstetter et al, "Uranium detection using small scintillators in a maritime environment," *Journal of Radioanalytical and Nuclear Chemistry*, 276, no. 2 (2008): 433-434.

## G. OVERALL ASSESSMENT OF ARAM

According to one source, the ARAM system technology, comprised of “proprietary algorithms, software and hardware initially developed by the Lawrence Livermore National Laboratory” and then licensed to IST-Textron Systems has all but exhausted its potential.<sup>303</sup> On the contrary, it continues to be developed through the cooperation of the partners above, as well as relevant third party institutions such as the Savannah River National Laboratory. Its sophisticated combination of hardware configuration and identification algorithms has proved a competent capability to detect and identify a wide spectrum of sources. Thus, ARAM is able to distinguish “innocent,” naturally occurring radioactive materials from hazardous medical and industrial isotopes, possibly illicit and intended for RDDs. It can also detect special fissile and source materials, which are definitely of proliferation concern and may be used for nuclear explosive devices or at least improvised ones.

However, as detailed in the relevant ANSI N42.43-2006 standard, even successful completion of all the radiation tests described in it, “should not be construed as an ability to successfully detect and identify all radionuclides in all environments.”<sup>304</sup> Prompt detection and identification depends, among other factors, on the source level of radiation, the shielding (whether intentionally surrounding the source or, in the case of a merchant vessel, merely intermediate in the form of machinery, cargo, and bulkheads), and on the distance between the source and the sensor. In real maritime interdictions, one does not usually have control over any of these crucial parameters.

Maritime interdictions offer *de facto* some optimistic prospects regarding ARAM’s performance. The levels of radiation to be looked for in a real interdiction scenario can be expected to exceed by large margins the few  $\mu\text{Ci}$  represented in the ANSI standard. The sensor-carrying Rigid-hull Inflatable Boat (RHIB) will be able to approach the target vessel as close as a few meters without interfering with its navigational safety

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<sup>303</sup> Berkeley Nucleonics Corporation, “Radiation Portal,” Berkeley Nucleonics Corporation, <http://www.berkeleynucleonics.com/radiationportal.html>.

<sup>304</sup> American National Standards Institute, Institute of Electrical and Electronics Engineers, and IEEE Xplore. *American National Standard Performance Criteria for Mobile and Transportable Radiation Monitors Used for Homeland Security*, 1.

or *mare liberum* rights. Also, the low level of maritime signal to background noise ratio greatly ameliorates the probability of detection of even comparatively weak signals, such as the ones of HEU, “at reasonable distances.”<sup>305</sup> Distance and shielding over an illicit radioactive source hidden amidst the machinery room of a 200,000 tons vessel will likely counterbalance these advantages and mask the presence of the source, however.

With the results of “Crawdad” still unavailable, Rudy Goetzman, Savannah River National Laboratory’s program manager, roughly outlined them in a recent statement, given on August 13, 2008: “Although range and sensitivity will vary, the detectors under development will be useful in seeking out - and also defining - nuclear materials from afar. [...] It will be sensitive enough to not only see and detect radiation sources, but also detect particular components of the source - the exact isotope.”<sup>306</sup> Hence, ARAM can significantly contribute to enhancing probable cause for maritime interdictions involving illicit nuclear materials. Even a harsh judge of ARAM’s efficacy cannot overlook the fact that – apart from the cases when the system cannot provide detection (in which the suspect vessel would in any case go un-interdicted unless existing approaches were enough to establish probable cause) – in all other cases in which ambivalent intelligence or surveillance data create doubt for the decision maker, a correlation with credible spectral analysis data, indicating the presence of a radioactive source not declared in the ship’s manifest and/or during the “hailing” procedure, automatically clarifies the situation.

In the course of these investigations, the author was able to perform theoretical and field experimental evaluations of the process of remote detection of radionuclides under maritime conditions using ARAM, a well-recognized state of the art detection technology. Based on these technical evaluations and an understanding of the legal and institutional issues related to probable cause determination, it is clear that such technology offers great promise in promoting effective interdiction operations that will improve safety and reduce the risk of illicit transport of radioactive materials.

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<sup>305</sup> K. J. Hofstetter et al, “Uranium detection using small scintillators in a maritime environment,” 438.

<sup>306</sup> Rob Pavey, “Boat-mounted radiation detectors being tested at Savannah River Site: Tool against terrorists.” Online Athens Banner-Herald, August 13, 2008, [http://onlineathens.com/stories/081408/news\\_2008081400393.shtml](http://onlineathens.com/stories/081408/news_2008081400393.shtml).

## V. CONCLUSION – NO PANACEA

Post-Cold War and September 11, 2001, developments have increased nuclear proliferation and nuclear terrorism as the most prominent security threats to the international community. For these reasons, and those addressed above, the maritime domain is pre-eminent in ensuring this security, especially through interdictions involving illicit radioactive materials. However, in order for these interdictions to be feasible, the issue of properly establishing probable cause must be resolved first. This issue represents a unique overlap of policy and technical considerations, an overlap that inevitably leads to the conclusion that there is no panacea. Instead, a constructive promotion of establishing probable cause requires a cohesive course of action, making use of both political means and technical information.

Probable cause includes both legal justification and reason for suspicion. Regarding the first component, the prospect of an enhanced UNSC resolution emerges as the most prudent solution, offering numerous advantages compared with the other potential alternatives described in Chapter III. First and foremost, it is based on amendment, and not reinterpretation, of international law. Reinterpretation, advocated by other proposed doctrines such as self-help, necessity, or anticipatory self-defence, contributes to the erosion of established international law and order and leads to an international society more prone to anarchy. These grave risks have been pointed out in relevant scholarship, with a widespread consensus on assessing reinterpretation approaches only as a last resort. Second, the alternative of amending international law through a new convention on the law of the sea could take decades-long negotiations, similar to those that preceded the one currently in force (UNCLOS III), which started on 1973, ended in 1982, and entered into force in 1994. Third, even if the amending process was opted for and implemented, it would only be binding on the states that ratified it. This is a serious drawback, since states of proliferation concern, like North Korea, would almost certainly not ratify it and hence would not be bound by its provisions. On the other hand, under Chapter VII and Article 25 of the UN Charter, enforcement actions, such as maritime interdictions, against any perceived threat to the international peace and

security can be authorized by the UNSC, and are legally binding to all states regardless. Moreover, under Article 103 of the UN Charter, a UNSC resolution “prevails over other entitlements in international law.”<sup>307</sup> Still, the prospect of such a resolution remains unlikely for as long as the policy concerns that resulted in the limited entitlement of UNSC Resolution 1540 remain.

Nevertheless, these policy concerns in respect to policing the oceans without disrupting legitimate navigation could be overcome with coordinated and parallel efforts in both operational and policy/legal fields. In the operational field, the key lies in the correlation of:

- i. intelligence information;
- ii. surveillance observations; and
- iii. radiation detection/identification data.

Arguably, such correlation can promote probable cause in two respects. The first, being less normative and more realistic, is that even within the existing, highly restrictive legal framework, a compilation of all these resources would signify that last resort options such as self-help, necessity, or anticipatory self-defense could be more thoroughly justified and invoked. For example, a relevant hypothetical scenario could be set by the following conditions: first, an initial suspicion set up after an intelligence tip that a foreign-flagged vessel bound to one of the interdicting state’s ports is carrying illicit radioactive materials; second, the cargo declaration of the suspect vessel provided during its “hailing” does not match with the detected presence of a radioactive material; third, there is no pretext under the law of the sea to board the vessel; and fourth, upon the request of the interdicting state to board the suspect vessel, there is a negative or no response on behalf of the flag state. In such a case, all available legal non-intrusive means would have been exhausted and the interdicting state would have solid grounds to board the vessel on the high seas even without the consent of the flag state, by invoking one of the aforementioned doctrines.

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<sup>307</sup> Klein, “Legal Limitations on Ensuring Australia’s Maritime Security,” 334.

The second involves probable cause enhancement based on the same concept of operations, but this time projected with normative means. Given that the international community has repeatedly affirmed that nuclear terrorism and proliferation are threats to its security in numerous UN resolutions, a new UNSC resolution on the policing of the oceans against radioactive materials could be enacted by setting mutually accepted rules of engagement (ROE). Rules of engagement are used by military and law enforcement agencies all over the world in order to determine when, where, how, and against whom force will be applied. ROE reflect the intentions of the political leadership<sup>308</sup> and can be tight or loose in their application. Existing practices of establishing probable cause through intelligence and surveillance are susceptible to a large extent to interpretation, manipulation, and lack of credibility. Therefore, they are not adequate by themselves to set tight ROE for maritime interdictions on the high seas, a precondition that seems indispensable in order to overcome some states' reluctance to consent to a UNSC resolution criminalizing the illicit transport of radioactive materials. This reluctance, reinforced by the states' fear of relinquishing sovereignty rights (expressed in the form of the exclusive flag state jurisdiction) and potential abuse of right resulting in harassment of legitimate shipping,<sup>309</sup> can only be overcome by establishing tight ROE that will ease this fear and ensure the least possible interference with the *mare liberum* principle. In this respect, adding the precondition that any intelligence-based evidence of suspicion must be correlated with "hailing" and radiation spectroscopy data can safeguard to a significant degree tight ROE and non-abusive maritime interdictions.

Moreover, regarding the policy/legal field, further promotion of probable cause would require cooperation in:

- i. Intelligence Sharing;
- ii. Technology Funding and Sharing; and
- iii. Balancing Sovereignty, Interests, and Security.

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<sup>308</sup> In Western standards through the Political Policy Indicators (PPI). See also [www.army.dnd.ca/lfaa\\_hq/arcon06/Annexes/Tact%20Instr%20F%20ROE.doc](http://www.army.dnd.ca/lfaa_hq/arcon06/Annexes/Tact%20Instr%20F%20ROE.doc).

<sup>309</sup> Klein, "Legal Limitations on Ensuring Australia's Maritime Security," 337.

Despite the fact that “poor intelligence estimates of Iraq’s WMD program enhance distrust for … intelligence services and challenge the credibility of future … intelligence assessments,”<sup>310</sup> intelligence should by no means be totally discounted as an option. One should not forget that in the vastness of the oceans and the multitude of ships sailing them, only two sources of establishing initial suspicion and exercising the right of approach exist; either an intelligence tip or the transit of a commercial vessel through a warship’s patrolling area. Therefore, intelligence sharing should be implemented by either strengthening existing structures or creating new complementary ones. In this respect, the dissemination of information among NATO members and PfP partners by CC-MAR Naples or the Terrorist Threat Intelligence Unit,<sup>311</sup> as well as among the PSI partners as part of the Statement of Interdiction Principles, is a step in the right direction.

As crucial as the sharing of intelligence is the sharing of technology. None of the ARAM related arguments made above will have any real and practical impact on the framework governing maritime interdiction operations, unless the relevant technology is shared and funded for further development. This kind of sharing, due to its less sensitive nature compared with intelligence, should not only be limited within the narrowly drawn limits of alliances (such as the Programme of Work for Defence against Terrorism<sup>312</sup>), but expanded to a much wider spectrum. In that direction, the much less controversial, in relation to the PSI, Global Initiative to Combat Nuclear Terrorism may prove very constructive. Though, according to Woolf, Kerr, and Nikitin, the Global Initiative to Combat Nuclear Terrorism faces constraints, such as lack of funding and consequent

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310 Warden, “Overcoming Challenges to the Proliferation Security Initiative,” 81.

311 Terrorist Threat Intelligence Unit is a permanent and not an ad hoc body for intelligence sharing established right after the September 11, 2001 attacks. See also Dagmar de Mora-Figueroa, “NATO’s Response to Terrorism,” NATO Review (Autumn 2005), <http://www.nato.int/docu/review/2005/issue3/english/art1.html>.

312 “This Programme was launched by NATO’s National Armaments Directors, who formally meet twice a year in a group known as the Conference of National Armaments Directors or CNAD, and is aimed at leveraging national expertise and research programmes to develop new and improved technologies to combat terrorism.” See Marshall Billingslea, “Military Matters-Combating Terrorism Through Technology,” NATO Review (Autumn 2004), <http://www.nato.int/docu/review/2004/issue3/english/military.html>.

skepticism on the part of the U.S. Congress,<sup>313</sup> it nonetheless constitutes a “flexible framework” to “prevent illicit trafficking by improving detection of such [nuclear] material.”<sup>314</sup> This framework also includes common exercises and sharing of doctrines, operational information, and technology via expert-level workshops.<sup>315 316</sup>

Lastly, it is important to point out that the adoption of a resolution that would grant states the *de jure* right of combating nuclear proliferation on the high seas similar to the already vested right of combating piracy and the slave trade<sup>317</sup> is overwhelmingly a matter of politics and to a far lesser extent a matter of all the other parameters, such as operational doctrines, intelligence, or physics applications. Currently, only part of the international community shares the same concern and urgency regarding the “need to rebalance states’ interests to enhance maritime security,”<sup>318</sup> despite the widespread consensus on the threats posed by nuclear terrorism and proliferation. Nevertheless, this kind of reconsideration on behalf of political leadership in balancing sovereignty, interests, and security is crucial unless the international community is willing to “wait for a seaborne WMD attack by terrorists before putting pen to paper.”<sup>319</sup>

In the words of the Head of the Planning Section in NATO’s Operations Division, Diego A. Ruiz Palmer, “Few security issues in the years ahead are likely to attract as much political attention as maritime security, due to its cross-cutting nature, straddling issues of international security, sovereignty, energy assurance, economic prosperity, law enforcement and defense.[....] [M]aritime security is one of the defining security

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<sup>313</sup> Amy F. Woolf et al., “Arms Control and Nonproliferation: A Catalog of Treaties and Agreements,” 34.

<sup>314</sup> Ibid.

<sup>315</sup> U.S. Department of State. Global Initiative to Combat Nuclear Terrorism, “Terms of Reference for Implementation and Assessment,” <http://www.state.gov/t/isn/rls/other/76421.htm>.

<sup>316</sup> “The International Atomic Energy Agency (IAEA) and the European Union (EU) have observer status. As of December 2007, 64 states have agreed to the statement of principles and are Global Initiative partner nations.” See Amy F. Woolf et al., “Arms Control and Nonproliferation: A Catalog of Treaties and Agreements,” 33.

<sup>317</sup> Persbo and Davis, “Sailing Into Uncharted Waters? The Proliferation Security Initiative and the Law of the Sea,” 75.

<sup>318</sup> Klein, “Legal Limitations on Ensuring Australia’s Maritime Security,” 334-337.

<sup>319</sup> Doolin, “The Proliferation Security Initiative: Cornerstone of a New International Norm,” 51.

challenges of this century.”<sup>320</sup> Arguably though, these contemporary conditions regarding maritime security are not without precedent. The issues of the slave trade and piracy/privateering in the 19<sup>th</sup> century were equally controversial and cross-cutting in nature,<sup>321</sup> as well as widely accepted state practices at the time. Nevertheless, the mere fact that they were ultimately addressed via consensus among all states and codified under the law of the sea as two of the formally enumerated reasons justifying the right of visit on the high seas, generates solid grounds for anticipating that combating illicit trafficking of radioactive materials will eventually obtain a similar status in the years to come.

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<sup>320</sup> Diego A. Ruiz Palmer, “New operational horizons: NATO and maritime security,” *NATO Review* (Winter 2007), <http://www.otenato.int/docu/review/2007/issue4/english/analysis4.html>.

<sup>321</sup> On one hand, the slave trade involved not only humanitarian issues, but also fears that “its abolition would [...] wreck the economy or merely benefit foreigners who would step into the market.” (See William Anthony Hay, “The Slave Trade’s Great Enemy,” *Wall Street Journal*, July 25, 2008, Eastern Edition.) On the other, piracy and its state-sponsored version, privateering, distinguished from one another only by the issuance of a letter of marque, involved to an even greater extent all of these issues, from international security to law enforcement and defense.

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